PACIFIC ISLANDS PROGRAM

University of Hawaii

Miscellaneous Work Papers

(1978: 1)

THE USE OF NEARSHORE MARINE LIFE AS A FOOD RESOURCE BY AMERICAN SAMOANS

Harry Burnette Hill

FOREWORD

The Pacific Islands Studies Program continues its interest in stimulating student efforts in research and contributions to Pacific Islands Studies. This stimulation frequently culminates in the publication of working papers authored by students. On occasion these working papers represent not finished products and should be regarded as initial endeavors in the study of the Pacific Islands. However, in the instance of this publication by Mr. Harry Burnette Hill entitled: "The Use of Nearshore Marine Life As A Food Resource By American Samoans" the work is judged to be more complete, more comprehensive and represents a more rigorous scholarly effort worthy of sharing.

This work, as a master thesis, by Mr. Hill is evidence of a creditable multidisciplinary study of the fisheries of American Samoa. More specifically, it is hoped that this study of American Samoa's subsistence fishery will have interest to anthropologists and to fishery and coral reef biologists. The study attempts to describe who does what, where it occurs, when it takes place as well as the why of this subsistence related activity, inasmuch as the fishery of these coral reefs represents a central aspect of marine resource utilization in American Samoa.

In the past this marine resource use has received limited attention, yet is judged to be most important in understanding the present island circumstances and most essential when engaged in intelligent planning of the future.

The editor wishes to thank those members of the Pacific Islands Studies Program publication committee for their review and recommendation for publication. Also, a special thanks to Ms. Michiko Kodama for her assistance in aiding in the preparation of the thesis for publication.

In addition to the cooperation of the University of Hawaii Pacific Islands oriented faculty members, a grant from the U.S. Office of Education to the Pacific Islands Studies Center has also aided in making this publication possible.

Mahalo.

Carl J. Daeufer, Editor
Pacific Islands Studies Center
Honolulu, Hawaii
August 1, 1978

The Use of Nearshore Marine Life

As A Food Resource By American Samoans

Harry Burnette Hill

Pacific Islands Studies Program

University of Hawaii

(1978: 1)

ACKNOWLEDGEMENTS

I would like to gratefully acknowledge the open and friendly co-operation of the people of American Samoa, for their ready willingness to stop and talk with the "palagi" scientist which allowed me to fully develop my research topic. In particular, I would like to express my appreciation to Fia Tiapula of Aoa and Mere Pritchard of Vaitogi for the friendship and information which each shared with me.

I would like to thank the members of my diverse thesis committee for the assistance each offered me in their particular field of study. My chairman, Dr. E. Alison Kay, provided me with encouragement and support and her excellent editorial advice. Dr. Robert Johannes, of the Hawaii Institute of Marine Biology, appeared on the scene half-way through the study's completion to inject an incredible amount of relevant information and useful direction into the thesis. Dr. Brian Lockwood, of the East-West Center's Institute of Technology and Development, provided insights into the Pacific's fisheries, its cultures and its socio-economic change. Dr. Floyd Tilton, of the University of Hawaii's School of Public Health, helped to develop a small amount of dietary information in the best way possible. All of these staff members of the University of Hawaii assisted in making this study a creditable interdisciplinary consideration of the subsistence fisheries of American Samoa.

And I would like to formally recognize the continual assistance and support of my wife and chief research assistant, Karen Janine, without whom this research would have been impossible. Whether the task was risking life and limb while diving in "awas" and along surf-beaten reef fronts or tediously editing and typing the finished product, she made this frequently lonely experience as fisheries biologist and researcher a team-effort.

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CHAPTER I

Introduction

The subsistence fisheries of the tropical Pacific traditionally provided the major portion of the protein in the diets of the peoples who inhabited the islands of Polynesia, Micronesia and eastern Melanesia (Alexander, 1902; Anell, 1955; Reinman, 1967). Utilizing a variety of generalized to highly specialized fishing techniques in their marine surroundings, Pacific fishermen harvested their catches from the bountiful coral reefs surrounding most of the high islands and all of the low islands (atolls) in the tropical Pacific. These fishing techniques included the use of nets, baskets, pots, stone traps, spears, bows and arrows and poisons, as well as hand fishing techniques and communal fish drives (Anell, 1955; Buck, 1930; Kennedy, 1962). Together with the cultivation of coconuts, breadfruit, bananas, plantains, taro and/or yams and the loose husbandry of chickens, pigs and dogs, the subsistence fisheries provided food for the needs of the inhabitants of the isolated Pacific island groups.

Fishing thus played a central role in the subsistence economies which supported self-sufficient communities of Pacific islanders. Island peoples drew upon the diversity of their tropical environments in supplying their daily needs. In spite of their inability to complement their limited resources through trade, the peoples of the Pacific shaped comfortable and secure lifestyles, well-adapted to harmonious interaction with the Pacific island environment.

Contact with the industrial nations of the world from the eighteenth century through the present has changed the traditional subsistence economies of the Pacific's island cultures considerably. The early introduction of Western ideas and materials by explorers, missionaries, whalers, traders and military and government personnel initiated processes of social and technological change which have swept through the islands of the Pacific at different rates for nearly two centuries. This metamorphosis has accelerated over the last three decades, for the increased Western interest in the Pacific which accompanied and followed World War II has prompted a second wave of change comparable in magnitude to that experienced during the early colonization of Pacific islands by the nations of the West.

As the economies of the Pacific islands have changed from subsistence to mixed economies, the traditional subsistence fisheries have changed too. A review of the literature suggests that these fisheries have characteristically declined with the increased availability of processed foods and of manufactured fishing equipment, becoming less varied and, very probably, less productive (Alexander, 1902; Smith, 1947; Van Pel, 1954-58). Such changes reflect general trends across the Pacific as island peoples increasingly rely upon foreign aid, family remittances and export-oriented employment to support their increasing levels of consumption and rapidly expanding populations.

The subsistence fishery of American Samoa is representative of Pacific island fisheries as they exist today, just as this American territory's social and economic conditions are characteristic of the route that development is taking in the Pacific. While probably having experienced less socio-economic impact than the fisheries of Hawaii, as much as those of Guam, Tahiti and New Caledonia, and more than those of most of the other islands of the Pacific, the subsistence fishery of American Samoa is described here as a sample of the direction taken within this traditional sphere of activity as Pacific cultures adopt market economies and integrate themselves in the modern world.

In order to better understand the subsistence fishery existing within the eastern islands of the Samoa group, we must establish its context. Detailed information of this nature is contained within the studies of Belshaw (1955), Coulter (1941), CH2M-Hill, Inc., (1976) and Wolfe Management Services (1969) in American Samoa, and the studies of Fox and Cumberland (1962), Lockwood (1971) and Pirie (1970, 1976) in Western Samoa.

The Territory of American Samoa is a possession of the United States which was acquired by treaties made during the early twentieth century and which is presently administered by the Department of Interior. It comprises the six eastern islands of the Samoan group and one other island (Swains Island) geographically belonging in the Tokelau group. These islands are located (approximately) at 14 degrees south latitude and 170 degrees west longitude. They esperience the moderate temperatures (21-32 C.), abundant rainfall (to 770 cm. in some areas), high humidity (76-83%) and moderate southeasterly tradewinds common in the southern tropics (CH2M-Hill, Inc., 1976).

The American Samoan Islands, like so many other high islands in the Pacific, are dominated by rugged volcanic mountains covered with lush tropical rain forests. The islands' steep mountain slopes and cliffs give way to generally narrow coastal plains which serve as sites for Samoan villages. Along the southern windward shores of the islands are found nearly continuous borders of fringing reefs, while along the northern leeward shores the reefs are generally found only within the bays which characterize these coastlines.

Since the 1899 cession of the territory to the United States, change has characterized conditions in the eastern Samoan islands, contrasting strongly with the cultural stability of previous millenia. The population has jumped from 5,000 to 30,000 inhabitants, while ten thousands of the islanders have emigrated to the United States (Wolfe Management Service, 1969). The economy has changed from that of numerous independent and self-sufficient coastal villages having little trade with one another to that of a united American territory receiving in excess of 30 million dollars in federal aid and expenditures yearly and generating several millions of dollars within its private sector (primarily tuna canning and light tourism), as well as receiving the additional moneys of family remittances supplied by "aiga" (extended family) members residing in the United States (G.A.S., 1975). The socio-political structure of the islands, while retaining the traditional "matai" (chief) system at the local level, has become a centralized system of government at the territorial level, with a governor, an elected bicameral legislature, a judicial system and a national identity. A system of public education through grade 12, as well as a community college, is in operation. Over 3,000 motorized vehicles use the islands' fifty miles of paved and unpaved roads (G.A.S., 1975). Several airlines use the islands' international airport. And thousands of televisions and radios receive the transmissions of the islands' broadcasting stations.

It is within the setting described above that the use of nearshore marine life as a food resource by the people of American Samoa will be considered. The primary area of study for this consideration was the largest island of the territory, Tutuila (Figure 1).

Historically the Samoans, like other Pacific islanders, depended largely upon their coral reefs and tropical seas for animal protein (Buck, 1930; Stair, 1897; Turner, 1884). While Beasley (1928, p. 22), in his review of Pacific fish hooks, judged the Samoans to have been both poor fishermen and indifferent makers of hooks, Buck (1930), Kramer (1902-03) and Stair (1897) recorded roughly 100 methods of fishing within the traditional Samoan subsistence fishery, testifying to the importance of the sea as a traditional source of food in these islands. The efficiency of this diverse fishing technology, acting in concert with traditional forms of reef conservation (Johannes, 1973), contributed to the self-sufficiency of the Samoan subsistence economy.

Yet the reef fishery of the present has dwindled in importance and in diversity to the point that some parts of it (diving, line fishing) seem to be as much sport fishing as subsistence fishing--the difference between the two lying primarily in the <u>necessity</u> of obtaining a successful catch. American Samoans no longer depend upon their traditional nearshore fishery as a primary source of food, for, although the sea around them abounds with marine life,

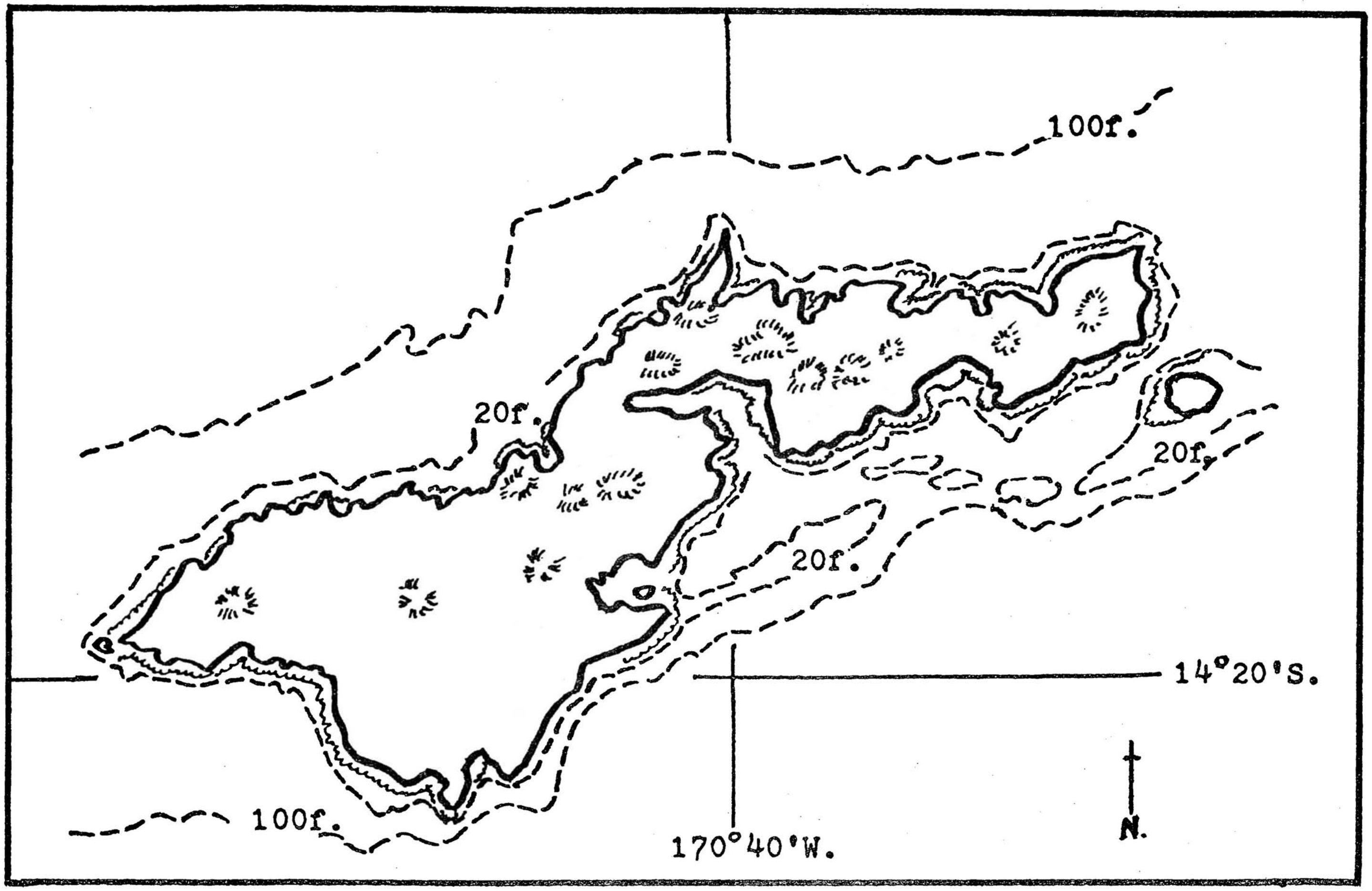


Figure 1. Map of Tutuila Island, the principal island of American Samoa, showing the major peaks of the mid-island volcanic mountain chain, the surrounding fringing reef, the southern barrier reefs and the depths of the offshore ocean, in fathoms

they rely upon imported, canned meats and fishes for their protein needs (Manar, 1969; Wolfe Management Services, 1969).

While it is unlikely that the reefs which contributed substantially to supporting a pre-contact population of about 5,000 islanders could support the present population of over 30,000, they nonetheless constitute a form of local production meriting conscientious management. Against an economic background of nearly complete dependence upon foreign aid from the United States, the need to nurture and revitalize local forms of production, whether they be traditional subsistence activities or new types of economic activity, is self-evident.

I believe that this study of American Samoa's subsistence fishery will have implications of interest to anthropologists and to fishery and coral reef biologists. The descriptions of "who does what, where, when and why" for the fishery of these coral reefs completes a central aspect of marine resource utilization which has received little attention in the past, but which is important to an understanding of the present and necessary to the intelligent planning of the future.

CHAPTER II

Materials and Methods

The information necessary for a holistic understanding of the nearshore subsistence fishery in American Samoa required that techniques for collecting and analyzing data be drawn from several disciplines. Methods common to the natural sciences included sampling techniques and various classification systems for different environmental parameters. Methods common to the social sciences included activity surveys, polls and interviews. I believe that the importance of this thesis lies as much in its interdisciplinary methods of studying the topic of subsistence fishing as in the quantitative descriptions that it provides.

This study centers around a road survey of the subsistence fishery along the coast of Tutuila between Faga'itua village, on the island's southeastern seaward coast, and Malaloa village, in the Pago Pago Bay area (Figure 2). Driving the 15.4 kilometers (9.5 miles) between these two villages at the posted speed of 25 m.p.h., and stopping when necessary, provided a convenient means for gathering substantial amounts of data on the subsistence fishery occurring on the fringing reefs.

The roadway offers an unobstructed view of the reef, and rarely moves more than 10 meters from the shoreline. In addition, the width of the fringing reef rarely exceeds

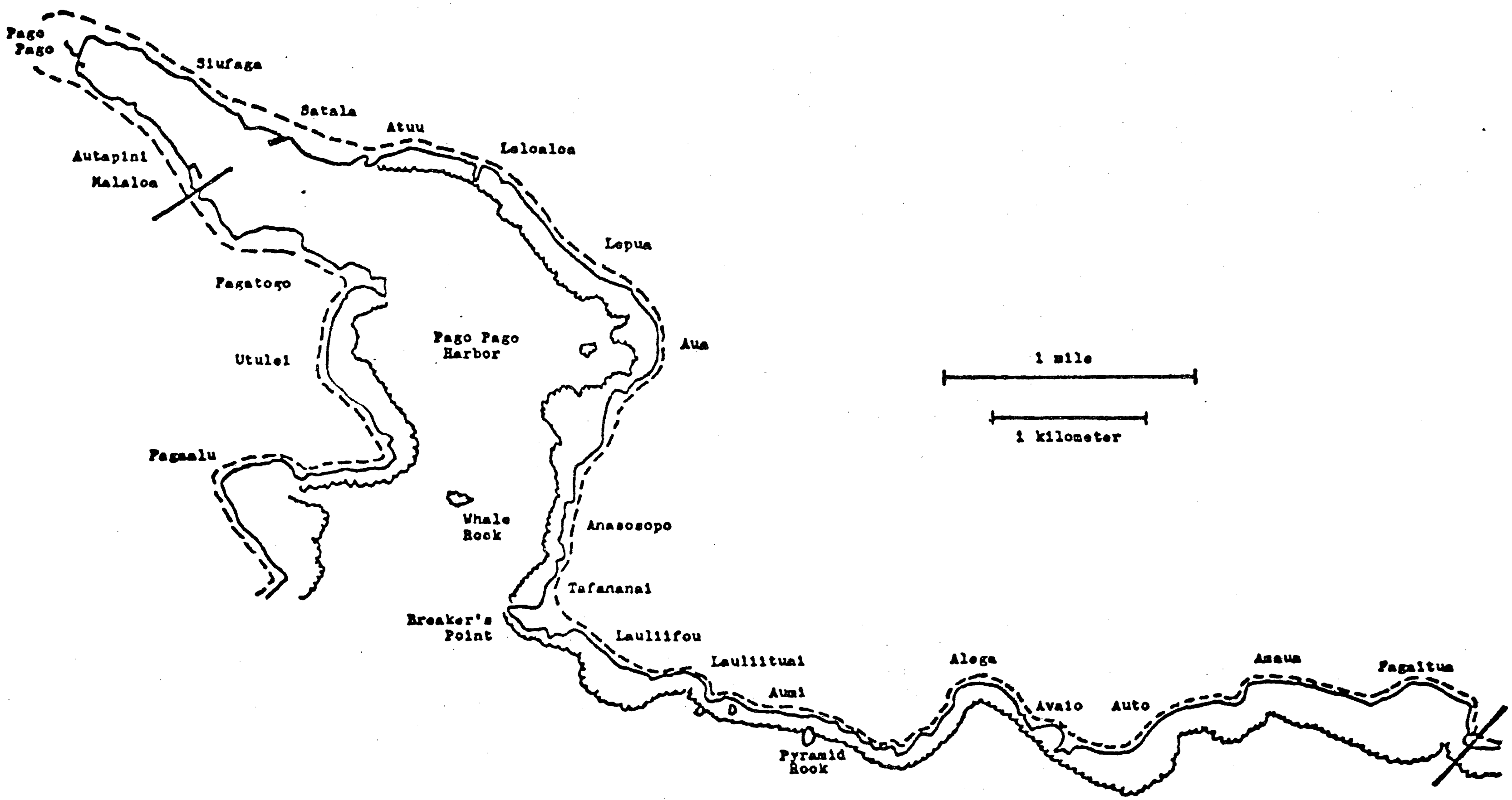


Figure 2. Map of the section of Tutuila's southeastern coast which was studied in road survey, showing the fringing reef and the Samoan villages

200 meters. Using a pair of 7 x 35 mm. binoculars to make observations while my wife, Karen, drove along the coastal highway, I recorded information on age, sex, group affiliation, locations, fishing activity and equipmentfor each individual whom I observed fishing. Information on cloud cover, precipitation, wind speed and direction, sea conditions and tidal conditions was obtained from the appropriate local agency or through direct observation and recorded for each road survey.

The schedule for these surveys, unfortunately, was largely dictated by our full-time jobs as high school teachers. Because of these commitments mid-days and nights are under-represented in the total collection of 133 road surveys. Naturally different tidal heights, tidal periods, sky conditions, wind conditions and sea conditions were sampled to varying degrees as well.

Analyzing the large volume of data accumulated over the course of eight months of study (12/75 through 7/6) required the use of computer programming. By defining a case as an individual fisherman, or as an empty set for surveys with no observations, frequencies and cross-tabulations were derived following SPSS (Statistical Package for the Social Sciences, Nie <u>et</u>. <u>al</u>., 1975). The codebook describing the variables and their values in this analysis is presented in Table 1.

Table 1. Codebook for the computer file SUBFISH, a study of the Samoan nearshore subsistence fishery, following the Statistical Package for the Social Sciences (Nie et.al, 1975)

SPSS Variable Name	Variable Description and Value Codes
CASENO	I.D. number of each case, a case being defined as an individual fisherman or an empty set
AGESEX	Age-group and sex of case 01. Male children, 5-14 yrs. 02. Female children, 5-14 yrs. 03. Male adolescents, 15-20 yrs. 04. Female adolescents, 15-20 yrs. 05. Male adults, 21-60 yrs. 06. Female adults, 21-60 yrs. 07. Elderly males, over 60 yrs. 08. Elderly females, over 60 yrs. 09. Male, non-child, 15-60+ yrs. 10. Female, non-child. 15-60+ yrs. 11. Missing value
FISHACT	Subsistence fishing activity observed 0. Paopao (outrigger canoe) 1. Walking and gleaning 2. Skin diving 3. Stationary pole fishing (line) 4. Sweeping pole fishing (line) 5. Rod and reef fishing (line) 6. Throw net fishing 7. Gill net/trap (=weir) fishing 8. Other methods (fish drives) 9. Missing value
EQUIP	Equipment being used 00. No equipment 01. Knife 02. Short spear/prod 03. Knife and prod 04. Goggles, knife and prod 05. Goggles and knife 06. Goggles and Samoan sling-spear 07. Mask and Samoan sling-spear 08. Goggles and speargun 09. Mask and speargun 10. Short bamboo pole (2-3 m) 11. Long bamboo pole (3+ m) 12. Rod and reel

SPSS Variable Name	Variable Description and Value Codes
EQUIP (cont.)	13. Throw net 14. Gill net 15. Paopao (outrigger canoe) 16. Gas lantern and gleaning equip. 17. Gas lantern, suspended, and diving equipment 18. UW light and diving equipment 19. UW light and gleaning equipment 20. Miscellaneous containers 21. Machete 22. Mask and knife 23. Mask and spear 24. Goggles 25. Weir 26. Mask 27. Handline 28. Goggles and crowbar 29. Machete and short sprear 30. Throw net and short sprear 31. Missing value
GROUPSIZ	Size of any group of fishermen, a group being defined by spatial proximity and interactions but not necessarily by similar activity 1-8. Real numbers 9. Missing value
AGEMIX	Indicates whether children were present with older fishermen in a group 0. Missing value 1. Unmixed, being either all children or all adolescent, adult and elderly Samoans 2. Mixed
SEXMIX	Indicates whether male and female Samoans from the adolescent, adult and elderly age-groups were present together within a group 0. Missing value 1. Unmixed 2. Mixed
VILLSITE	Village or landmark adjacent to fishing activity 01. Faga'itua

SPSS Variable Name	Variable Description and Value Codes
VILLSITE	02. Amaua 03. Auto 04. Avaio (Two dollar beach) 05. Alega 06. Pyramid Rock 07. Aumi 08. Lauliituai 09. Lauliifou 10. Tafananai-Anasosopo 11. Aua (outer) 12. Aua (bend) 13. Lepua 14. Leloaloa 15. Atuu 16. Satala-Siufaga 17. Pago Pago 18. Autapini-Malaloa 19. Malaloa Annex Pier 20. Empty set (MV)
REEFLOC	Location on the reef 0. Shore 1. Inner reef (=1/3) 2. Mid reef (=1/3) 3. Outer reef (=2/9) 4. Reef margin (=1/9) 5. Reef front/slope and awa (excurrent channel) 6. Deep water off of the reef 7. In transit 8. Pier 9. Empty set
RUNNO	I.D. number of data-gathering run
TOTAL	Total number of fishermen observed during one data-gathering run, excluding those involved in fishing from the piers
PIERTOT	Total number of fishermen observed fishing from the piers during a data-gathering run

SPSS Variable Name	Variable Description and Value Codes
DAY	Day of the week 1. Weekday 2. Saturday or holiday 3. Sunday
TIME	Time block of the day 1. Early morning, 5 AM- 8 AM 2. Midday, 8 AM- 2 PM 3. Afternoon, 2 PM- 5 PM 4. Evening, 5 PM- 7 PM 5. Night, 7 PM-10 PM 6. Late night, 10 PM- 5 AM
TIDE	Tidal height, grouped 1. Very low, -1.0 to +0.2 ft. 2. Low, +0.3 to +1.4 ft. 3. Mid, +1.5 to +2.6 ft. 4. High, +2.7 to +3.8 ft.
CEILING	Cloud cover 1. Sunny 2. Partly cloudy 3. Cloudy 4. Overcast
PRECIP	Amount of precipitation recorded at the Tafuna Weather Station for the day
WIND	Conditions of the wind recorded at the Tafuna Weather Station for the nearest hour
SEAS	Conditions of the ocean's surface 1. Calm 2. Slight 3. Moderate 4. Heavy, with whitecaps 5. Missing value (nights)
TIMETIDE	Tidal period 1. Low, within 1½ hrs. 2. Middle period of tidal cycle 3. High, within 1½ hrs.

Frequencies and cross-tabulations were applied to 1156 cases observed along the selected length of coastline and to 294 cases observed fishing from the large piers at the Satala Marine Railway and the Malaloa Annex. An additional 186 cases recorded during partial road surveys along different stretches of Tutuila's coast were included in the analysis of those variables which are applicable to the entire island, rather than to the Faga'itua-Malaloa section.

In some analyses it was necessary to adjust the counts of fishermen categorized according to the values of a variable under study, correcting for the sampling errors produced by irregular road surveys. Such adjustments were completed for the cross-tabulations of fishing activity by tidal height and by tidal period (Tables 11 and 12) and for cross-tabulations of reef locations by tidal height and by tidal period (Tables 13 and 14). The formula for deriving such adjustments is:

Adjusted count=

Actual count x Sampling correction x Total correction

where

Actual count= the number of cases counted in a value-category of the variable under study

Sampling correction= (the largest number of data-gathering runs in any value-category of the variable under study)/(the number of data-gathering runs in the value-category under consideration)

Total correction= (the total number of data-gathering runs taken for the variable under study, representing the sum of the runs in all this variable's value-categories)/((the number of value-categories in the variable under study)x(the largest number of data-gathering runs in any value-category of the variable under study))

Another method of collecting data was that of interviewing Samoans while they were involved in fishing activities. As the questionnaire used in these interviews (Table 27) indicates, I was interested in obtaining detailed personal and interpersonal information, fishing information and catch information. These interviews generally took about 15 minutes and, in almost all cases, the people with whom I talked were very co-operative.

To estimate catches I used a Chatillon spring scale (Model 1N-30). I generally sought out Samoans who had completed their fishing and who were returning homeward.

Altogether I conducted 79 such interviews, speaking to one fisherman and seeking information about the entire group. The distribution of these interviewed groups, according to their fishing activities, was as follows:

27 in gleaning activities

30 in line fishing activities

11 in diving activities

8 in throw net activities

3 in gill net retrievals

The catches recorded usually represented the efforts of more than one fisherman, and the reliability of catch estimates for all fishing efforts was consequently improved.

In addition to the information obtained about the subsistence fishery, its participants, their activities and their catches, these interviews allowed me to confirm my ability to discern the age-group, sex and co-operative affiliations of the individuals as I observed them from the road. I found that my accuracy for each of these evaluations was as follows:

100% for the sex of the fishermen

97% for the age-group of the fishermen

96% for the co-operative affiliations of the fishermen

To obtain additional information concerning who was fishing, how each fishing activity was carried out, what were the optimal conditions for each fishing activity and how the catch was being used and distributed, I carried out longer interviews (Table 2) in Samoan homes and "fales" (open houses). In several cases, notably Fia Tiapula of Aoa and Mere Pritchard of Vaitogi, the interviews went well beyond the prepared questions.

During the summer months I lived in each of three villages for one week. In Faga'itua, Lauli'ifou and Aua I was able to carry out round-the-clock observations of each village's fishing activities, adding time-continuum information to the point-in-time data gathered in the road surveys. I was also able to trace out the paths used by fishermen involved in different types of fishing activities. Finally, these weeks of in-village study allowed me to expand the number of interviews which I had conducted previously.

A similar week of in-village study was spent in the Manu'a islands during April of 1976. Unfortunately heavy surf and neap tides all but eliminated fishing activity during this period, though a Manuan friend, Sao, and I did get out for two days of spearfishing. I was unable to return to Manu'a to carry out further study of American Samoa's truly rural villages.

To obtain information about student participation in the subsistence fishery and about the importance of the fishery's catch in the family diet, I polled several of my classes with questionnaires presented as "an inquiry into Samoan life." This approach was necessary because Samoans provide unreliable information when they are aware of the implications of their answers to an interviewer.

Through this student poll I obtained a large body of information about the students' morning, afternoon and evening activities, and about the composition of their families' morning and evening meals. The questions asked of the 97 students are presented in Table 29.

To obtain information about the distribution of marine life from the nearshore reefs through the market places I questioned the managers of Tutuila's principal commercial food outlets.

Finally, I randomly sampled the fringing reefs of Faga'itua, Lauli'ifou and Aua to determine the general character of the zones on each of these reefs, using a weighted quadrat measuring one meter square. I cast the quadrat ahead of me as I followed a roughly predetermined course across the reef. These courses across the reefs were determined with the aid of aerial photographs, provided by the G.A.S. Department of Public Works (Aero Services, 1971), which helped me to discern probable reef zonation. Using a diving mask and snorkel in making observation, I described the contents of each quadrat sample (substrate, sessile macro-organisms) to my wife, who recorded the information. With a considerable number of such quadrat samples taken for each of the three village's fringing reefs, I produced a general scheme of the zonation characterizing American Samoa's fringing reefs.

In order to estimate the surface area of these reefs I used a Lasico Mechanical Planimeter (Model 120) on the topographic map of Tutuila Island produced by the Department of Interior's Geological Survey (scale= 1;24,000).

Together these different methods of obtaining data permit a holistic description of the subsistence fishery in American Samoa: the reef environment in which it operates, the reef life which it harvests, the fishermen, the fishing techniques, the sensitivity of the fishing activities to environmental parameters and the importance of the fisheries and their catch to the Samoan way of life.

CHAPTER III

The Setting: a High Island's Fringing Reef

The section of Tutuila's coast selected for study is representative of the island's shoreline and its fringing reefs. Depicted in Figure 2, the area between Faga'itua and Malaloa, emcompassing 15.4 kilometers of coastline, includes both coast exposed to the open sea and coast protected within Pago Pago Bay. This area is characterized topographically by a narrow coastal plain ranging from 50 to 550 m. in width and by steep volcanic mountains rising to heights of 550 meters. Towards the sea a narrow, shallow fringing reef ranging from 50 to 200 m. in width drops steeply to depths of 50 to 100 m. (Figure 1).

While the coast under study did not include the rugged cliffs which fall into deep seas without a shallow fringing reef, the promontories of Pyramid Rock and Breaker's Point served to indicate that these areas are not utilized to an appreciable extent in the subsistence fishery. Such coasts characterize much of Tutuila's northern shore and most of Ta'u Island in the Manu'à Group.

Environmental conditions along exposed and protected coasts differ in several important aspects. First, the fringing reef which faces the open sea is exposed to considerably more wave action than is the reef lying within the bay. As a result the seas along the reef front are much rougher and currents across the reef are stronger for the fringing reefs facing the open sea. Second, the area within Pago Pago Harbor receives more rainfall (to 500 cm.) and stream runoff than do other areas of Tutuila's coast (to 320 cm.) (CH2M-Hill, Inc., 1976). The periodic outpourings of freshwater streams and their heavy sediment loads into the confines of the bay do much to produce a different type of fringing reef.

In addition, the reef within the harbor has been exposed to human alteration to a much greater extent than has the reef along the open sea. The mass emissions of effluents containing a high BOD by the tuna canneries, whose sewage receives only primary treatment, and the filling of approximately one quarter of the harbor's reef flats, with the consequent changes in tidal exchange and the harbor water's residence time, have produced increased stresses upon the biological community within the inner harbor (Sun *et*. *al*., 1975). Dredging these harbor reefs for landfill has also seriously altered their nature in several cases.

In order to better understand the impact of these differences upon the reef ecosystem, the fringing reefs adjacent to three villages were studied as described above. In this comparison both broad similarities and significant differences become apparent.

Figure 3. Aerial photograph of Faga'itua village and its adjacent reef

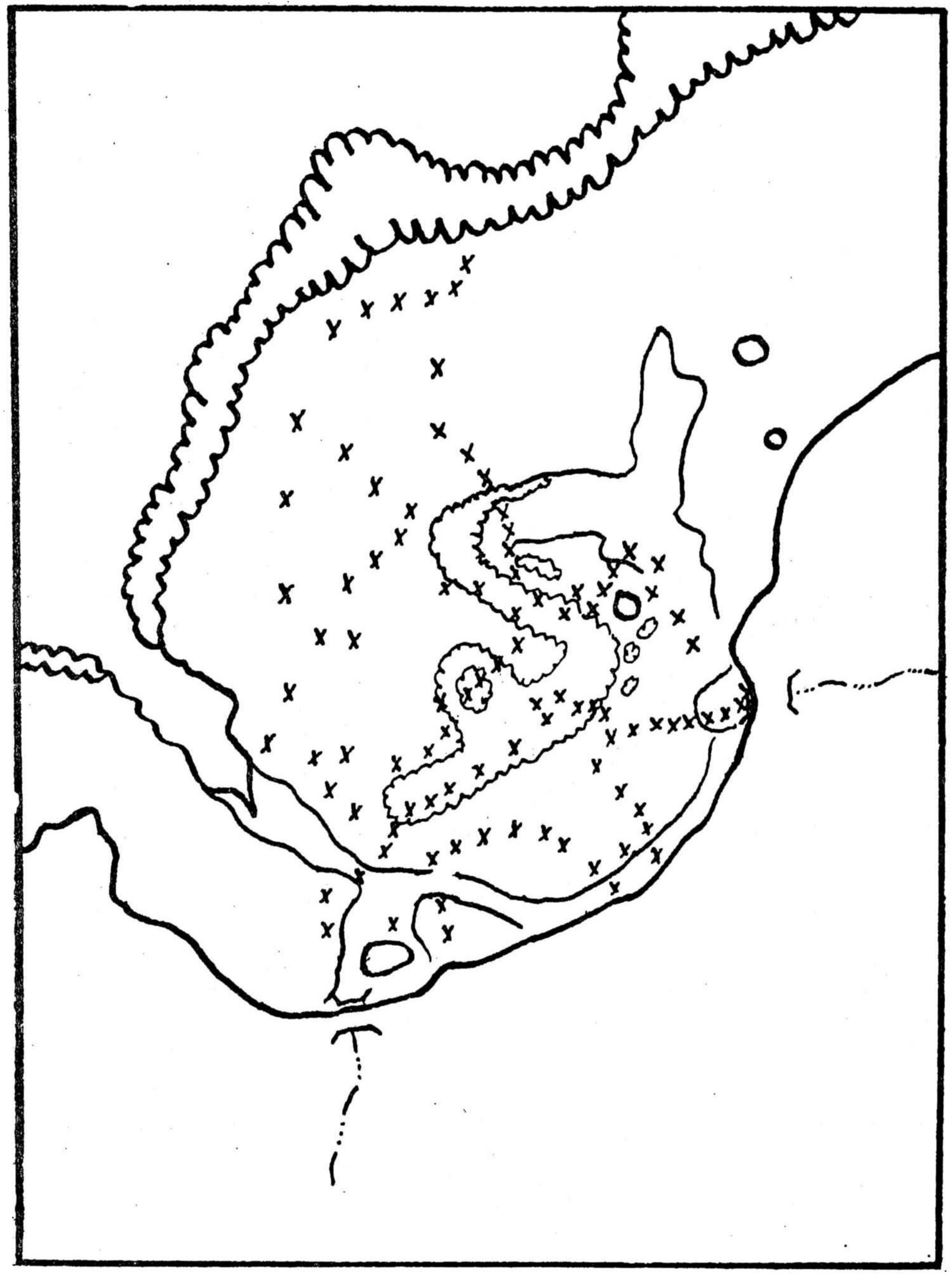


Figure 4. Diagram of Faga'itua reef, showing the track of its random quadrat survey

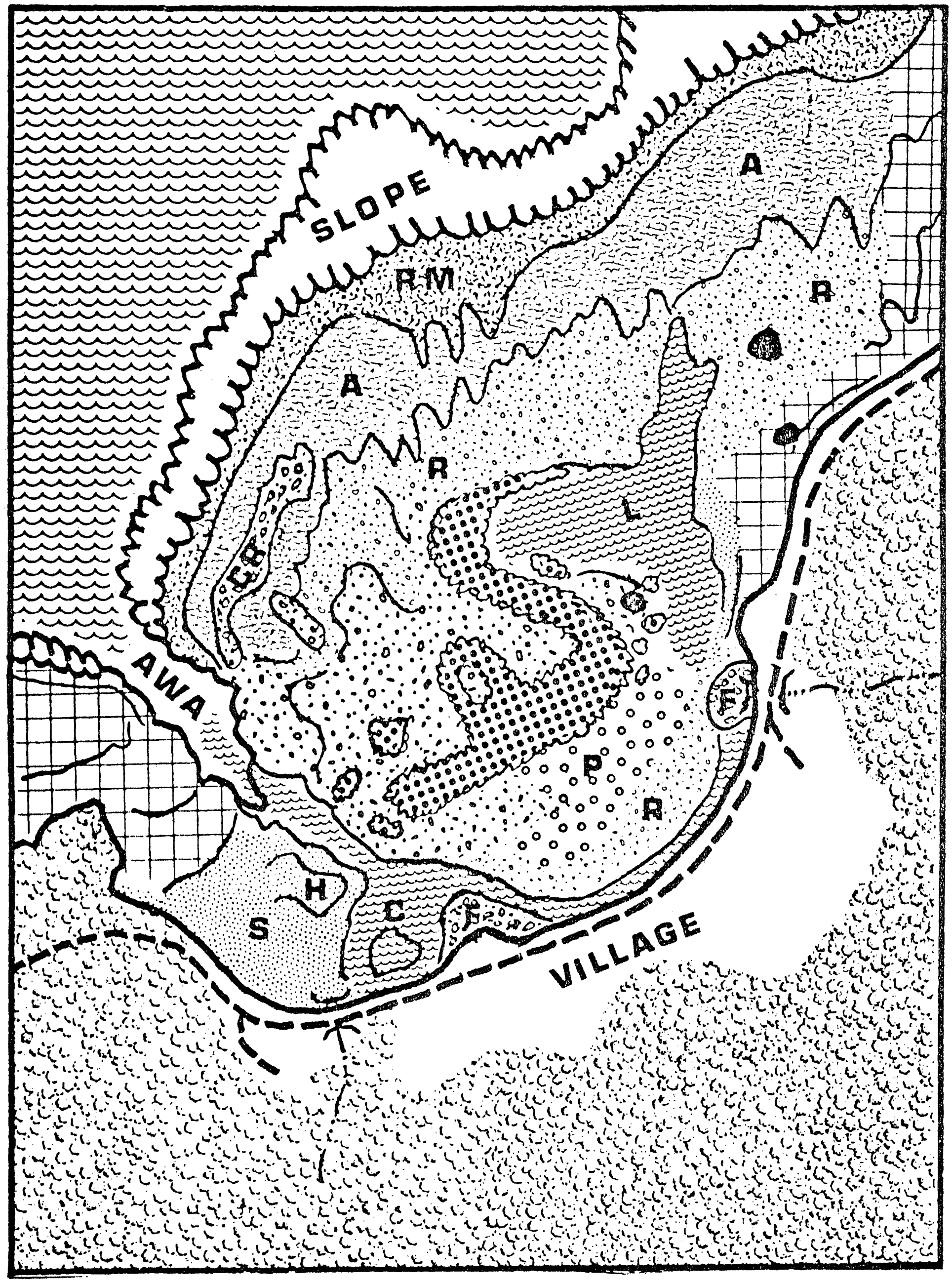


Figure 5. Diagram of Faga'itua reef, showing its
ecological zones

Key to Figure 5. Diagram of Faga'itua reef, showing its ecological zones

(from shore to deep sea waters)

Shoreline

consists of a 2 meter high bed of basaltic boulders reinforced with concrete, and broken by numerous culverts and drainage pipes; drops sheerly to the reef, sand or channel of the primary shoreline

Gravel fans

F D= +0.0 to +0.4 m., moderate relief
consists of stream-deposited beds of basaltic rocks and gravels

Runoff channels

C D= -2.4 to -0.6 m.
consists of steep-sided runoff channels with bottoms of basaltic rocks and gravel, coral debris, roadside litter and mixed sediments; dredged

Sand flats

S D= -0.6 to +0.4 m.
consists of assorted sands on a consolidated coral shelf

Porites platform

P D= -0.6 to -0.3 m., moderate relief
consists of scattered heads of massive *Porites lutea*, with significantly smaller quantities of *Psammocora contigua*, *Porites andrewsi*, *Pavona frondifera* and staghorn Acroporans, and with considerable quantities of reef debris; live coral cover= approx. 40% of bottom
edible epifauna: *Echinometra mathaei* ("tuitui"), at densities of 14.6/ $m.^2$

Mixed coral platform

M D= -0.6 to +0.0 m., low relief
consists of *Psammocora contigua*, with significantly smaller quantities of staghorn Acroporans, *P. frondifera*, *P. decussata* and *Porites* spp., and with considerable quantities of reef debris; live coral cover= approx. 50% of bottom
edible epifauna: *E. mathaei*, at densities of $13.6/m.^2$

Halimeda flats

H D= -0.6 to -0.4 m.
consists of a patchy mat of *Halimeda* growing on the sand flats

Acroporan thicket

D= -1.0 to -0.2 m., high relief
consists of the branched staghorn Acroporans, *A. formosa* and *A. samoensis*, intact Acroporan skeletons covered with filamentous algae and patches of sand and coral debris; live coral cover= 30% of bottom; intact coral skeletons= 50% of bottom
edible epifauna: *E. mathaei*, at densities of 9.0/$m.^2$, and *Diadema* sp. and *Echinothrix* sp., at densities of 0.1/$m.^2$

Shallow sandy lagoon

D= -2.0 to -1.0 m.
consists of a sandy lagoon with scattered patches of staghorn Acroporans; live coral cover= approx. 10% of bottom
edible epifauna: *E. mathaei*, at densities of 0.4/$m.^2$

Pavona platform

D= -0.6 to -0.4 m., low relief
consists of *Pavona decussata*, with significantly smaller quantities of *P. frondifera*, *Pocillopora damicornis*, *Porites convexa* and staghorn Acroporans, on a consolidated reef substrate; live coral cover= approx. 60% of bottom
edible epifauna: *E. mathaei*, at densities of 15.6/$m.^2$. and *Holothuria* sp. ("loli"), at densities of 0.1/$m.^2$

Coral rubble flats

D= -0.3 to +0.2 m., with coral blocks up to 1 m. high
consists of coralline algae covering a semi-consolidated floor of coral rubble, with some benthic algae
edible epifauna: *Holothuria* sp., at densities of approx. 0.2/$m.^2$, and *Turbo* spp., at densities of less than 0.1/$m.^2$

Coralline algae flats

D= -0.1 to +0.2 m., with coral blocks up to 1 m. high
consists of coralline algae covering a consolidated reef floor, with scattered numbers of hardy reef corals, notably *Acropora humilis* and *Pocillopora verrucosa*, seaward; live coral cover= approx. 5%
edible epifauna: *Holothuria* sp., at densities of approx. 0.2/$m.^2$, *Turbo* spp. ("alili"), at densities of less than 0.1/$m.^2$, and *Diadema* and *Echinothrix* spp., at densities of less than 0.1/$m.^2$

Reef margin

D= -0.2 to +0.4 m., moderate relief
consists of a Porolithon ridge with scattered numbers of hardy reef corals, *Acropora humilis*, *A. leptocyathus*, *Pocillopora verrucosa* and other unidentified species; considerable wave action prevented an estimate of the live coral cover

Reef front

consists of a moderately sloping reef, dropping to a depth of about 20 m. within 100 m. of the reef margin; characterized by a low-profile groove-and-spur system

Ava

D= -2.0 to -10 m.
consists of a reef canyon with sheer to overhanging walls which accomodates the primary excurrent flow for Fagaitua reef and the streams which empty out on it

Faga'itua

The village of Faga'itua and its adjacent reef, shown in Figure 3, lie somewhat sheltered within Faga'itua Bay. This fringing reef has a gradually sloping reef front characterized by a low-profile groove-and-spur system of coralline algae and hardy reef corals. The shoreline, the midreef *Acropora* thicket (dark), the well-defined excurrent "ava" (reef canyon or ravine) and the runoff channels (dredged) which feed into it are also evident in this aerial photograph.

In the random quadrat survey of this reef (Figure 4) the zonation of the substrate types and bottom cover, suggested by Mayor (1924) and by Helfrich and Maragos (Helfrich et. al., 1975) in their studies of Samoan reefs, was delineated. As detailed in Figure 5 and its accompanying key, these zones are, from shore to sea:

1) Rocky shore	Shore
2) Gravel fans	Inner reef
3) Runoff channels	
4) Sand flats	
5) *Porites* platform	
6) Mixed coral platform	
7) *Acropora* thicket	Midreef
8) Shallow lagoon	
9) *Pavona* platform	

10) Rubble flats — Outer reef

11) Algal flats — __

12) Porolithon ridge — __Reef margin

13) Reef slope — Reef front

14) "Ava" — __

The particular nature of these zones, including bathymetric information, the percentage composition of the bottom types, the species composition of the dominant corals and the approximate densities of the edible epifauna, is provided in the above-mentioned key.

That the degree of zonal specification could be increased to include more categories or decreased to reduce the number of categories is obvious to the marine biologist familiar with coral reefs. It is my intention to maintain this degree of analysis and to allow the reef uses by subsistence fishermen to redefine this zonal scheme.

Lauli'ifou

The village of Lauli'ifou and its adjacent reef lie completely exposed to the southeast trades which frequent the tropical seas south of the equator during the months of May to November. This reef is also exposed to the full force of breakers generated by winds and storms from the south, and was observed to experience the largest breakers along the coastline under study (to 4+ m.). The extent of the breaking waves' turbulence (white) is evident in the

Figure 6. Aerial photograph of Lauli'ifou village and its adjacent reef

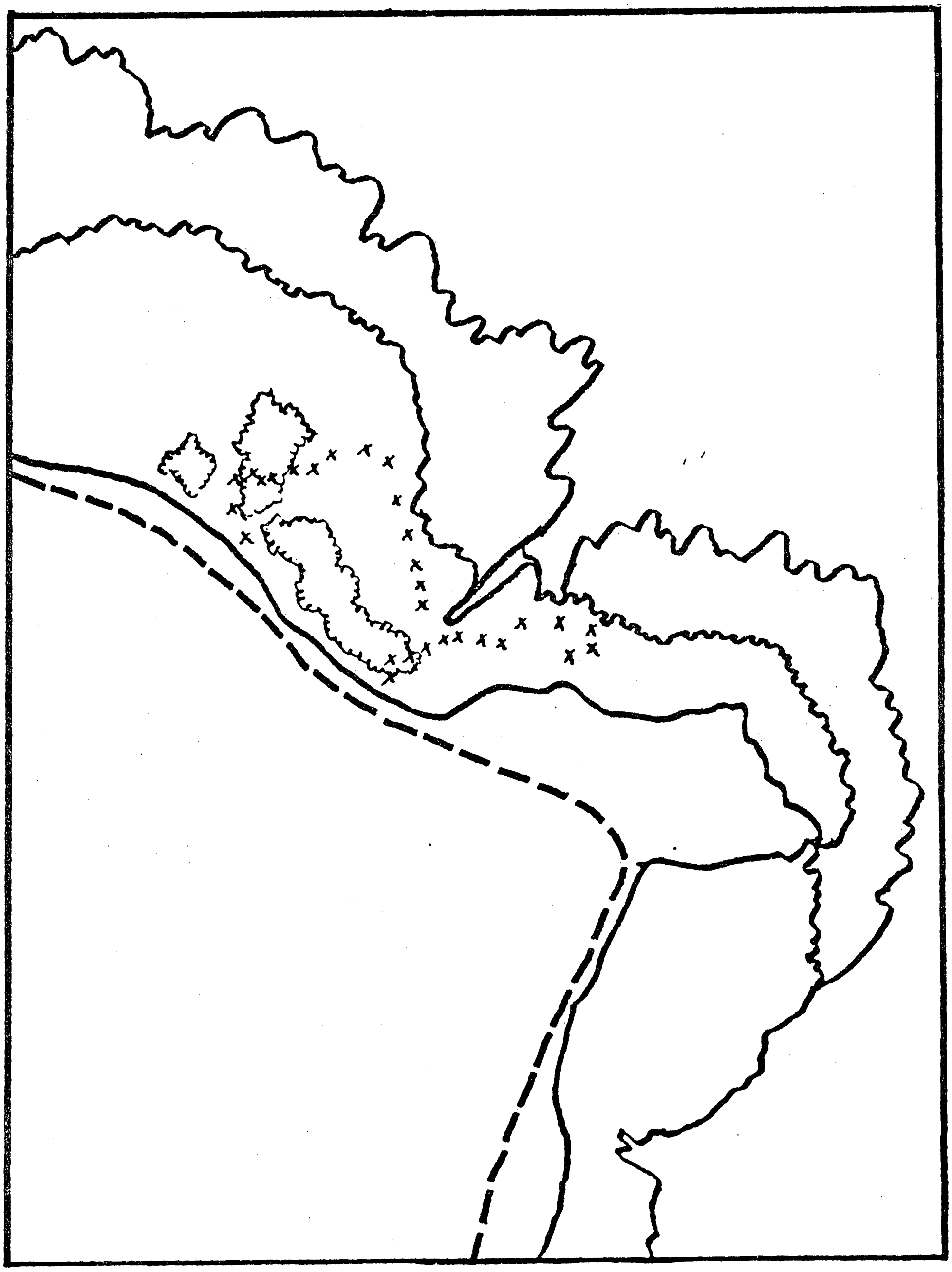


Figure 7. Diagram of Lauli'ifou reef, showing the track of its random quadrat survey

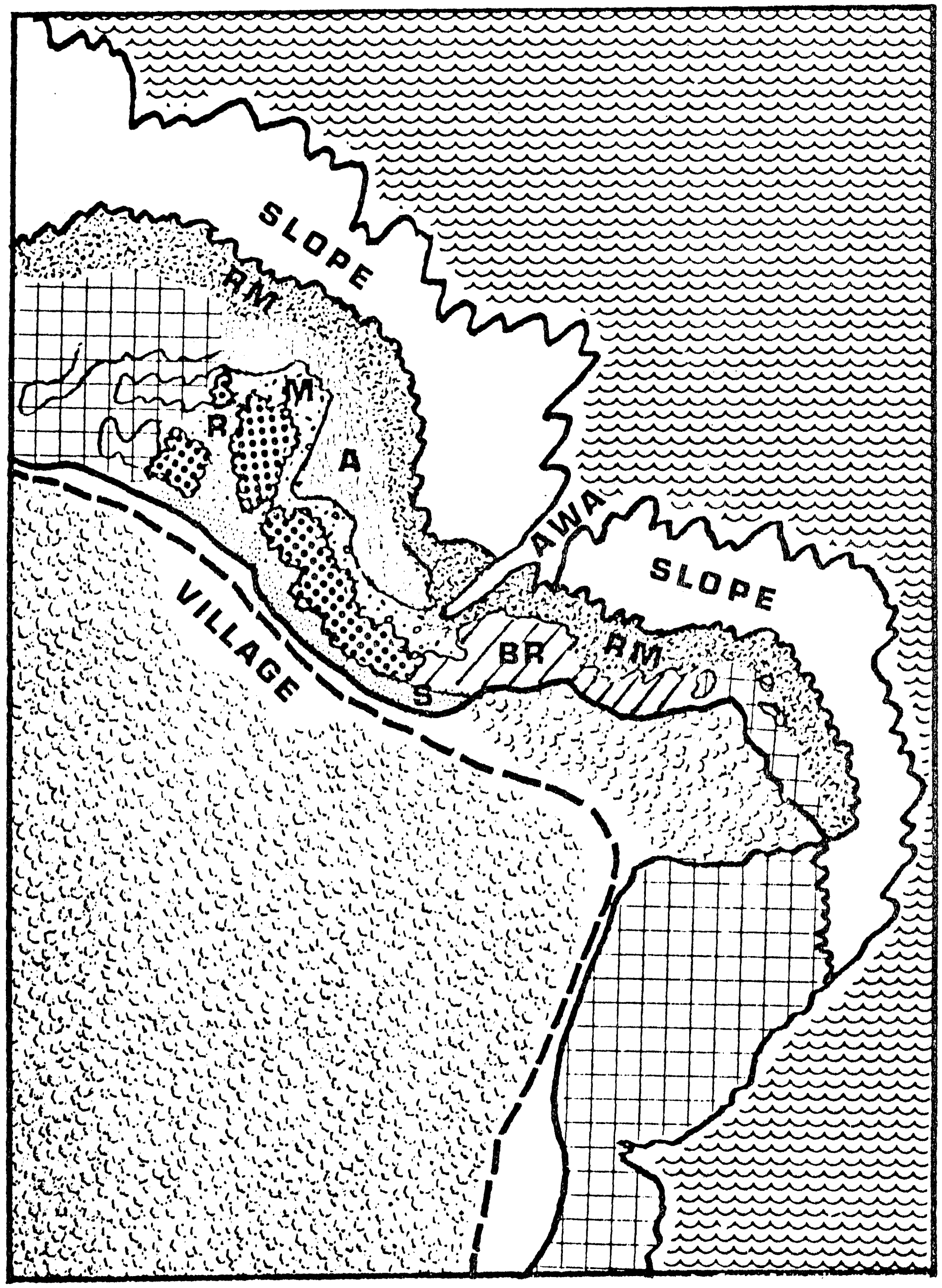


Figure 8. Diagram of Lauli'ifou reef, showing its ecological zones

Key to Figure 8. Diagram of Lauli'ifou reef, showing its ecological zones

(from shore to deep sea waters)

Shoreline

consists of a 2 meter high bed of basaltic boulders reinforced with concrete or of steep cliffs to 30 meters height, both of which drop steeply to a narrow sandy beach or to a consolidated coral bench

Sandy beach

D= -0.6 to +0.6 m.
consists primarily of coralline sands covering a consolidated coral bench, with increasing amounts of large reef debris on the beach's eastern end

Acroporan thicket

D= -1.2 to -0.1 m., high relief
consists of the branched staghorn Acroporans, *A. formosa* and *A. samoensis*, intact Acroporan skeletons covered with filamentous algae and patches of sand and coral debris; live coral cover= approx. 50% of bottom; intact coral skeletons= approx. 30% of bottom
edible epifauna: *Echinometra mathaei*, at densities of $0.2/m.^2$, and *Diadema* sp., at densities of less than $0.1/m.^2$

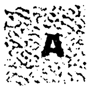
Broken reef

D= -0.8 to -0.2 m., moderate relief
consists of a rugged consolidated reef of coralline algae and assorted reef corals, including *Montipora elschneri*, *Pocillopora* spp. and *Acropora* spp., broken by sand-filled channels and potholes; live coral cover= approx. 25% of bottom

Mixed coral platform

D= -0.6 to +0.2 m., low relief
consists of a semi-consolidated to consolidated reef of coralline algae and a diverse assortment of reef corals, including *M. elschneri*, *Psammocora contigua*, *Porites convexa*, *Pocillopora* spp. and *Acropora* spp., with considerable quantities of benthic algae

Coralline algae flats



D= -0.2 to +0.2 m., low relief
consists of coralline algae covering a semi-consolidated to consolidated coral reef floor, with some benthic algae and hardy corals; scattered blocks of coral to 1 m. heights strewn across its surface

Reef margin

(Due to high surf a close survey was not possible.)
consists of a *Porolithon* ridge with scattered numbers of hardy reef corals

Reef front

consists of a moderately to steeply sloping reef, dropping to depths of about 50 m. within 50 m. of the reef margin, and to considerably greater depths towards Breaker's Point; characterized by a high-profile groove-and-spur system

Ava

D= -1.0 to -10 m.
consists of a reef canyon with sheer to overhanging walls which accomodates the primary excurrent flow from Lauliifou reef and the intermittent flow of stream runoff

aerial photograph of the reef, as is the high-relief groove-and-spur slope which it produces (Figure 6). Also evident are the high cliffs of Breaker's Point, the sandy beach, the Acropora thicket (dark) and the excurrent "ava."

In the random quadrat survey of this reef (Figure 7) the zonation of the substrate types and bottom cover was delineated. As detailed in Figure 8 and its accompanying key, these zones are, from shore to sea:

1)	Cliffs	Shore
2)	Sandy beach	
3)	Acropora thicket	Inner reef
4)	Broken-relief reef	to
5)	Mixed coral platform	Mid reef
6)	Coralline algae flats	Outer reef
7)	Porolithon ridge	Reef margin
8)	Reef slope	Reef front
9)	"Ava"	

Aua

The village of Aua and its adjacent reef, shown in Figure 9, lie sheltered within Pago Pago Bay directly below monolithic Mt. Pioa, the "Rainmaker." Because of its position in relation to the Rainmaker, the Aua reef receives runoff from one of Tutuila's largest streams (Lalolamauta Str.). This stream's runoff produces the extensive sand flats, frequently covered with silt-laden estuarine waters, which are discernible along the lower half of the Aua reef. It may also have contributed to the existence of the reef sill between the patch reef and the fringing reef's margin. Other reef features evident in the aerial photograph are the rocky shore, the dredged lagoon, the sheer reef front and the several "avas."

In the random quadrat survey of the Aua reef (Figure 10) the zonation of the substrate types and bottom cover was delineated. As detailed in Figure 11 and its accompanying key these zones are, from shore to sea:

1)	Rocky shore	Shore
2)	Sand flats	Inner reef
3)	Finger *Porites* platform	to
4)	Coral rubble flats	Mid reef
5)	Dredged lagoon	
6)	*Porites*-*Pocillopora* platform	
7)	Mixed coral platform	Outer reef
8)	Algal flats	
9)	*Porolithon* ridge	Reef margin
10)	Reef slope (sheer)	to
11)	Secondary reef sill	Reef front
12)	"Avas"	

Figure 9. Aerial photograph of Aua village and its adjacent reef

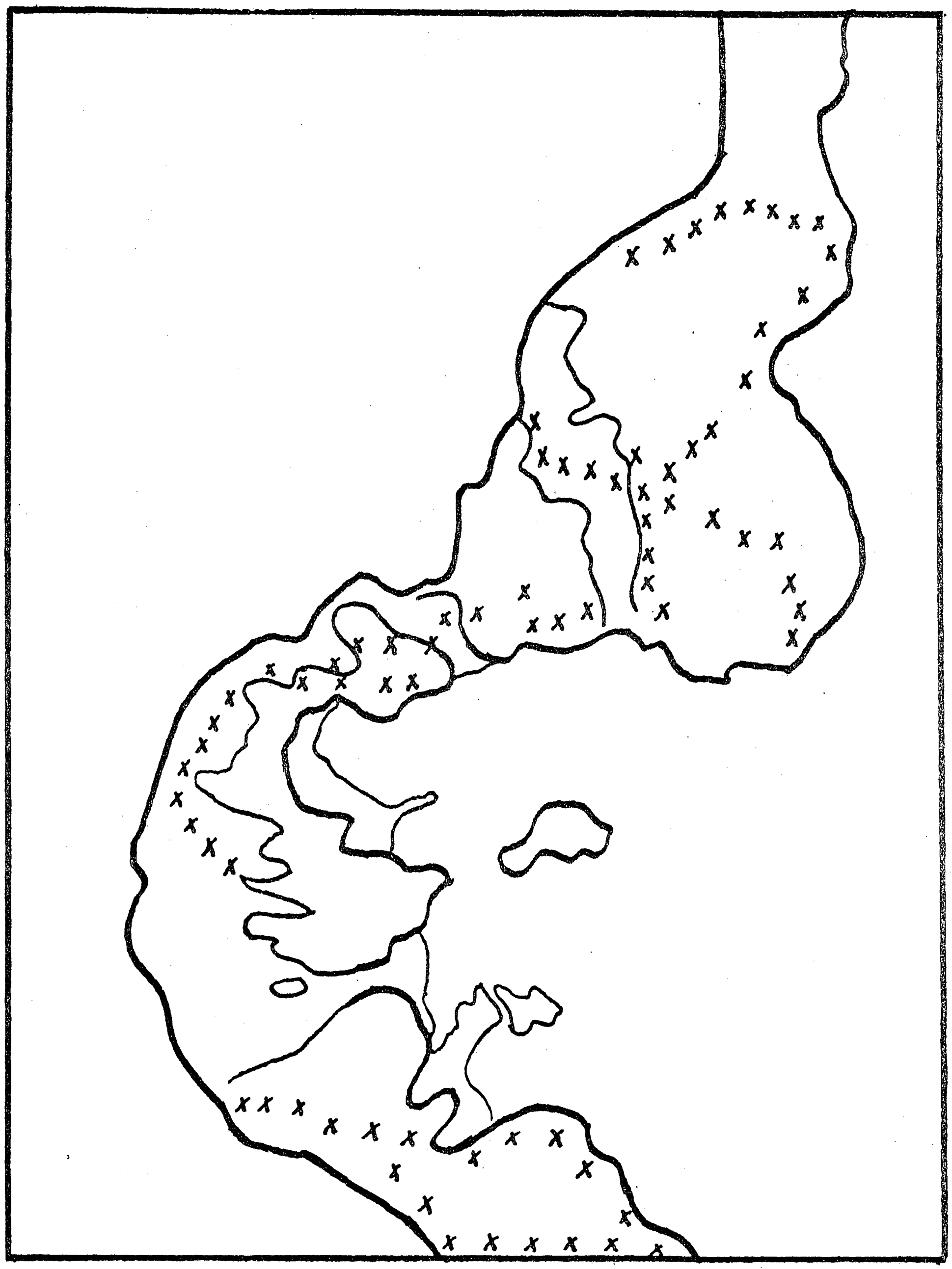


Figure 10. Diagram of Aua reef, showing the track of its random quadrat survey

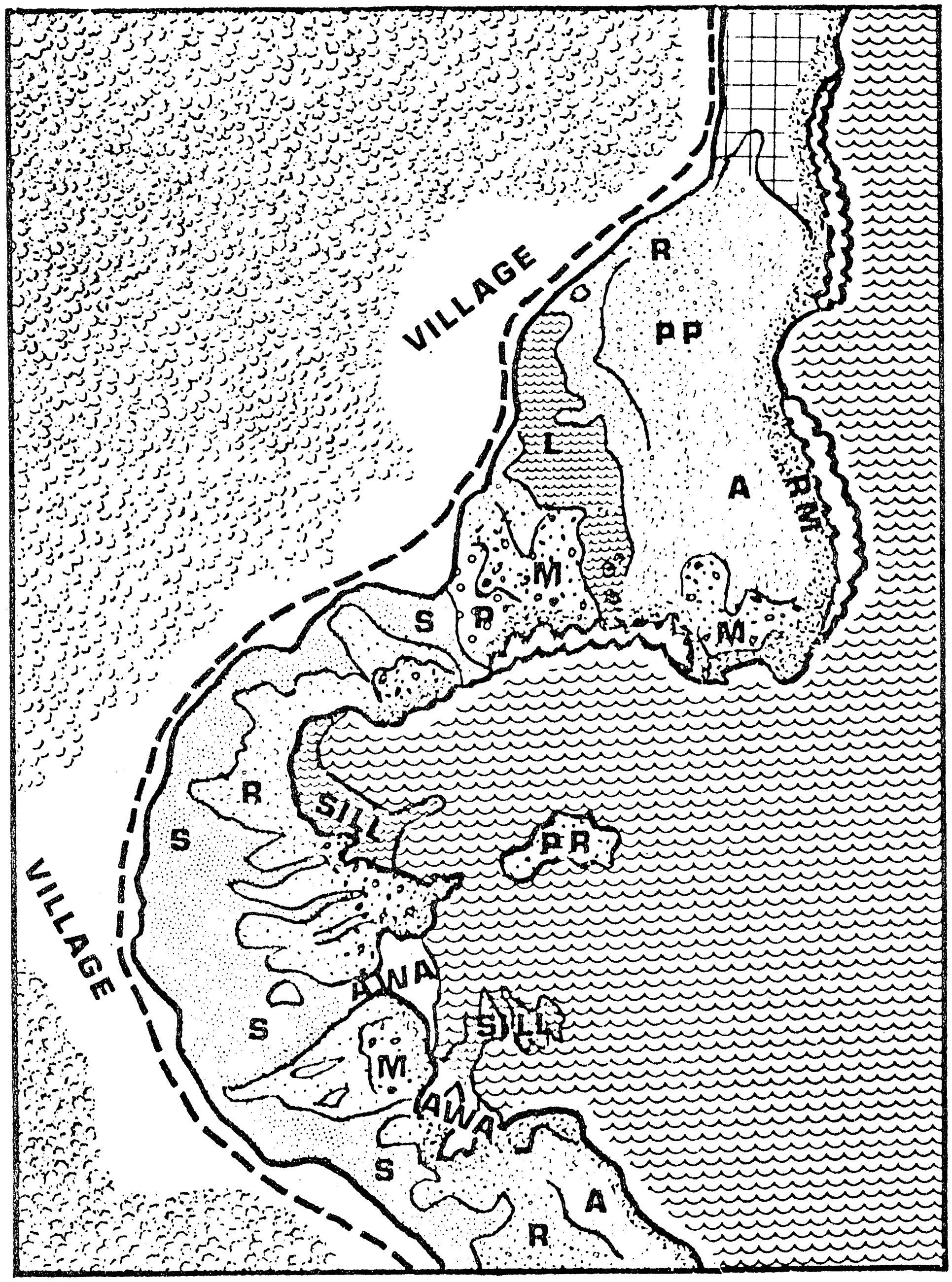


Figure 11. Diagram of Aua reef, showing its ecological zones

Key to Figure 11. Diagram of Aua reef, showing its ecological zones

(from shore to deep sea waters)

Shoreline

consists primarily of a low-profile rocky shore with a narrow sandy beach along much of its length; broken by several culverts for the drainage of mountain streams

Sand flats

D= -0.8 to +0.0 m.
consists of calcareous and terrigenous sands, and of exposed coral and basalt rocks; patches of *Halimeda* and benthic algae prominent on rocky areas, with soft corals and sponges more dominant towards its periphery

Branched Porites platform

D= -1.0 to -0.2 m., moderate relief
consists of branched *Porites andrewsi* attached to loose calcareous boulders projecting above the sandy bottom, with some massive *Porites*; live coral cover= approx. 40% of bottom

Coral rubble flats

D= -1.4 to -0.3 m.
consists of coral rubble, calcareous sand and occasional blocks of coral rock; live coral cover = approx. 5% of bottom
edible epifauna: *Echinometra mathaei*, at densities of 0.7/m.^{2}, and *Diadema* and *Echinothrix* spp., at densities of 0.1/m.^{2}

Dredged lagoon

D= -3.0 to +0.0 m.
consists of a lagoon dredged for landfill, with sheer sides and a bottom of calcareous sand with some reef debris; branched *Acropora* spp. and *Pocillopora* spp. conspicuous in its seaward pass, and *Porites* throughout

Pocillopora-Porites platform

D= -1.0 to -0.3 m.
consists of a consolidated reef floor dominated by *Pocillopora damicornis* and small heads of *Porites lutea*, with clusters of juvenile *Acropora formosa* and other staghorn acroporans; live coral cover= approx. 15% of bottom
edible epifauna: *Holothuria* sp., at densities of 0.2/m.^{2}, and *Diadema* and *Echinothrix* spp., at densities of less than 0.1/m.^{2}

Mixed coral platform

D= -0.8 to -0.2 m., low relief
consists of *Psammocora contigua*, *Pavona* spp., *Porites* spp. and *Pocillopora* spp. on a consolidated reef floor; live coral cover= approx. 35% of bottom
edible epifauna: *Echinometra mathaei*, at densities of 0.2/m.^{2}

Algae flats

D= -0.5 to +0.0 m.
consists of calcareous and benthic algae covering a semi-consolidated to consolidated coral reef floor, with calcareous sand in crevices and coral blocks strewn across its surface; some *Pocillopora* spp; live coral cover= approx. 5% of bottom
edible epifauna: *Echinothrix* and *Diadema* spp., at densities of 0.2/m.^{2}, and *Turbo* spp., at densities of 0.1/m.^{2}

Reef margin

D= -0.2 to +0.2 m., moderate relief
consists of a poorly developed *Porolithon* ridge, with an abundance of different hardy reef corals, espcially *Acropora leptocyathus*; live coral cover= approx. 35% of bottom
edible epifauna: *Turbo* spp., at densities of 0.2/m.^{2}

Reef front

consists of a sheer reef slope dropping to a reef sill or to the harbor bottom

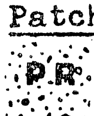
Ava

D= -5.0 to -0.8 m.
consists of a wide and relatively shallow reef canyon with sheer walls which accomodates the primary excurrent flow and stream runoff from Aua reef

Reef sill

D= -5.0 to -1.0 m.
consists of a deep, sloping reef sill covered with numerous corals; extremely turbid area

Patch reef



D= -1.0 to -0.2 m., low to moderate relief
consists of a coral pedestal rising from depths is excess of -10 m., with numerous assorted corals upon its surface

General scheme of zonation

A general scheme of zonation arises from the study of the Faga'itua, Lauli'ifou and Aua reefs. This pattern is believed to be characteristic of the fringing reefs throughout the Samoan islands. It may also be typical of zonal schemes found on the fringing reefs of other high islands in the Pacific as well, for it compares well with the study of a Guam reef by Marsh (1974).

The shore is of basalt, and may rise several meters to a coastal bench or rise many meters as a coastal cliff. In areas where the curvature of the shoreline offers shelter from the strong currents which sweep the reefs, a narrow sandy beach and adjoining sand flat may occur, with scattered patches of *Halimeda* on the latter.

The inner reef is frequently strewn with considerable coral debris and sediment. The dominant corals are *Porites andrewsi*, *Porites lutea* aff. and *Psammocora contigua*, with some variance from reef to reef. As a consequence of the dominance of these corals, the bathymetry is ofter moderately irregular, with variations of as much as 0.8 m. in the bottom depths across a relatively level basement.

The middle regions of the fringing reefs characteristically contain platforms of *Pocillopora*, *Porites* and *Pavona* spp. On wider sections of the fringing reef (100+ m.) thickets of staghorn acroporans may occur. While this wasn't found to be true of Aua's reef, Mayor (1924) indicated that Acropora was a dominant component of this reef prior to the extensive dredging and filling of the last several decades. Dr. Arthur Dahl, of the South Pacific Commission, notes that small, juvenile Acropora spp. currently form a significant portion of the bottom cover at Aua and suggests that the reef is undergoing repopulation by these fragile corals in an upcoming article in Pacific Science (Dahl and Lamberts, "Environmental Impact on a Samoan Coral Reef," 1978). Where Acropora thickets do occur, the bathymetry is highly irregular (1-2 m.); otherwise the bathymetry is slightly to moderately irregular.

The outer reef's seaward edge consists of a Porolithon ridge, with the hardy corals Acropora hyacinthus, A. humilis, A. leptocyathus, Pocillopora verrucosa and Millepora platyphilla (a fire coral). Shoreward of this rich coral zone are algal flats of consolidated to semi-consolidated reef overlain by coralline and filamentous benthic algae. This region may contain coralline rocks to one meter plus diameters upon its surface, and deposits of coral rubble may accumulate along its inner margin.

Finally, the reef margin is broken by excurrent "avas" or canyons. These cut through the outer reef, the Porolithon ridge and the reef slope as a channel for water sweeping across the reef and for stream runoff. The reef front consists of the "avas" and the reef slope, which may be moderately to steeply sloped. The entire region, including both the reef margin and the reef slope, is characterized as the groove-and-spur system of tropical coral reefs occurring in exposed areas.

Within this broad zonal scheme are significant differences in the fringing reef harbored within the bay and that exposed to southerly winds and swells along the open sea coast. The reefs' seaward slopes receive considerably more wave action along the open sea's coast and are consequently of greater relief and of more gradual slope. The bathymetry of the seaward reef slopes is reminiscent of the groove-and-spur system found along the windward sides of coral atolls, while the sheer reef front of the fringing reef within the bay is akin to the precipitous face of an atoll's leeward side. The mid reef is likely to contain a healthy growth of staghorn acroporans along the open sea's coast. Where stream runoff is heavy, as in Pago Pago Harbor, *Porites* and *Pocillopora* are the dominant midreef corals. Finally, the differences in currents and in runoff combine to produce large sand flats within the bay, and in other sheltered areas, while such sand flats are generally restricted along the open sea coast.

The above-noted similarities between Tutuila's fringing reefs and the reefs of coral atolls must be tempered with the important differences which exist between the two.

Most importantly, the fringing reefs around Tutuila, as around most Pacific high islands (Mayor, 1924), has no large lagoon. Also significant is the absence of large predatory sharks which pose a serious threat to diving in an atoll's deeper waters.

Each of these regions or ecological zones on the fringing reefs present the fisherman with different obstacles and with different rewards. Because there are important differences in the environmental conditions across and along the reef, the marine life found in different places varies accordingly. While deep regions with adequate shelter (indicated by bathymetric relief and coral cover), notably the midreef *Acropora* thickets and the reef front, harbor resident populations of fish, the shallow areas of the reef margin, outer reef and inner reef are visited by fishes migrating with tidal and diurnal cycles to forage in these productive areas. Among invertebrates some edible species, like the octopus, sea urchins and some sea cucumbers, are found over the entire reef, while other species, like the epifaunal gastropod grazer, *Turbo*, the infaunal bivalve, *Gafrarium*, and the migrating spiny lobster, *Panulirus,* are found in particular areas or during particular times. In addition to using methods capable of catching different types of marine life, the fishermen must overcome the obstacles presented by depths, bathymetry, wave action and other environmental parameters which vary between reef zones.

After discussing the subsistence fishery and its participants, the fishery's interaction with the reef environment will be considered.

CHAPTER IV

The Subsistence Fishery and Its Participants

The many types of subsistence fishing have traditionally provided the primary source of animal protein in the diets of Pacific islanders, supplemented by the chickens and pigs generally reserved for feasting. In the Pacific islands fishing became literally a fine art, for upon its success depended the alternatives of plenty or a close approach to starvation (Gudger, 1927, p. 211). Consequently cultural adaptation to marine food sources produced a complicated fishing technology in which individual fish species were not infrequently pursued with unique devices and techniques peculiar to them alone (Gudger, 1927; Reinman, 1967).

Early western observers in the Pacific recorded some of the multitude of techniques utilized in traditional subsistence fisheries (LaPerouse, 1797; Stair, 1897; Turner, 1884) and later anthropologists complimented these early records with their research (Anell, 1955; Beasley, 1928; Buck, 1930; Kramer, 1902-03).

Yet the traditional fisheries in the Pacific had changed considerably by the beginning of the twentieth century. The field observations of Alexander (1902) and Cobb (1902) indicate that a reduction in the variety of methods and the replacement of some traditional materials and devices with imports had occurred when they conducted their studies from the U.S. Bureau of Fisheries vessel, Albatross. The vast array of wood and bone hooks had been replaced, for the most part, by manufactured metal hooks. The native fibers used in nets and fishing lines had been replaced by manufactured materials and equipment. Native outrigger canoes were observed to lack the quality of earlier forms, particularly in regions having heavy contact with Western nations, and to have been replaced by whaling boats in cargo uses. Apparently the technology of the Pacific subsistence fisheries quickly changed with Western contact, and fishermen adopted the materials made available through contact and trade with the industrial nations of the world.

Adaptations have continued with the passage of time. Kennedy (1962), Smith (1944, 1947) and Van Pel (1958) provide excellent reports of the myriad of techniques used in catching numerous marine animals for subsistence purposes in the central Pacific in the mid-twentieth century. Hosaka (1944) and Titcomb (1952) present additional information on nearshore fishing in Hawaii. Together these sources describe the nature of Pacific fishing as it exists today and reveal the considerable changes which have occurred in methods and equipment.

Table 2. A summary of the long interview forms used, showing its questions and the information drawn from the compiled answers

I. The questions: A Sample Questionnaire (compacted)

Interview #:

Date:
Location:
Age:
Sex:

1. How long have you been living in Samoa?
2. What is the highest level of education that you have completed?
3. What is your occupation?
4. What is your family's yearly income?
   a. Less than $2000
   b. $2000 to $5000
   c. $5000 to $7000
   d. More than $7000
5. In what ways do you obtain food from the reefs?
6. How much time do you spend in one day fishing this way?
7. How many days a week do you spend fishing this way?
8. What foods do you obtain from these fishing activities?
9. What special methods are involved in this type of fishing?
10. What are the best conditions of sun, wind, sea and tide for fishing in this way?
11. What are the worst conditions of sun, wind, sea and tide for fishing in this way?
12. In what way do you use the plants or animals that you gather or catch?
13. How many meals a week do you eat foods from the sea which members of your family have caught?

II. The answers: A Compilation of Information Useful to This Study (N of questionnaires=23)

1. Personal information
   a. Time in Samoa: usually lifetime (87%)
   b. Highest level of education:

none	5%
grade school	25%
high school	25%
technical school	20%
some college	5%
bachelor's	5%
master's	5%

c. Jobs;

students	13%	
teachers	17%	
public employee	8%	
private employee	4%	
cannery worker	8%	
*fishermen-farmers	25%	(83% on Manu'a)
unemployed	25%	(67% on Manu'a)

d. Yearly income:

less than $2000	46%	(83% on Manu'a)
$2000 to $5000	54%	(71% on Tutuila)
$5000 to $7000	0	
more than $7000	0	

2. Primary subsistence fishing information:
   a. Sexual division of labor
      males dive, and use throw net, gill net, paopao, rod and reel and bamboo poles
      females glean and use bamboo poles
   b. Fishing techniques
      gleaning: walk the reef and pick up the marine life you seek; poke in holes for octopus
      pole fishing: bait hook with meat or fish, using no lead or float, and place in position off of shore or of the reef's edge, called "tautau"; attach feathered flies and drag across surface, aalled "seuseu"
      rod and reel: using lure or spoon, cast across the reef or over the reef margin; using baited hook with weights, cast from shore
      diving: spear fish or crustacean that you want from the surface; use light at night
      throw net fishing: throw the net over a school of fish, when you see them; it helps to have a "spotter" up high
      gill net fishing: place the gill net across a small "'awa" or near a large one and leave overnight; place and retrieve during high tides
      paopao fishing: the"paopao", a small outrigger canoe, is used in conjunction with other types of fishing (above), especially at night
   c. Optimal fishing conditions
      gleaning: low tide, moderate temperatures with some cloud cover
      line fishing: moderate temperatures with some cloud cover, moderate winds or less, moderate breakers or less; bright moon when using flies at night
      diving: moderate to calm seas, moderate breakers or less

throw net fishing: bright sun overhead, calm breakers
gill net fishing: calm seas, calm breakers, dark nights-cloudy or slight moon
paopao fishing: adequate water to clear reef, moderate wind or less, calm seas

Taken as a whole, the change in fishery technology has been characterized by the replacement of highly refined and very specific techniques and materials with simplified, generalized methods of fishing. Much of the expertise of the Pacific's traditional subsistence fisheries, retained through the oral repertoires of island cultures, has been lost with the islanders' conversion to manufactured goods and the cash economy which underlies their exchange.

The changes in the nature of the subsistence fishery activities in American Samoa are representative of some of the qualitative changes which have occurred throughout the Pacific. Approximately one hundred different types of fishing methods were recorded in nineteenth century Samoa, among which techniques involving nets, scare-lines, traps of stone and wood and spears dominated. Fishing techniques requiring the co-ordinated actions of large groups of fishermen, under the direction of a "tautai" (fishing chief), were of greater importance than were solitary fishing methods (Buck, 1930; Stair, 1897). Today these many methods of harvesting the sea have dwindled in number and their natures have likewise changed (Table 2, II2b).

The histogram (Figure 12) depicting the frequency with which different fishing activities were observed along Tutuila's fringing reefs presents the relative importance of each of nine categories. This quantitative analysis of

```
    CODE
              I
        0     ****** (     53)
              I  PAOPAO ACTIVITY
              I
              I
        1     ***************************************** (    408)
              I  WALKING-GLEANING
              I
              I
        2     *************************** (    265)
              I  DIVING
              I
              I
        3     ******************** (    195)
              I  FISHING, POLE-BAIT
              I
              I
        4     *** (     22)
              I  FISHING, POLE-FLIES
              I
              I
        5     ***** (     41)
              I  FISHING, ROD
              I
              I
        6     ******* (     63)
              I  THROWNET FISHING
              I
              I
        7     ****** (     47)
              I  GILL NET OR TRAP
              I
              I
        8     ** (     11)
              I  OTHER METHODS
              I
              I
        9     ****** (     50)
  (MISSING)   I  MISSING VALUE
              I
              I.........I.........I.........I.........I.........I
              0        100       200       300       400       500
              FREQUENCY
```

Figure 12 Histogram depicting the frequency with which the different primary subsistence fishery activities were observed

Table 3. Frequency with which the different primary subsistence fishery activities were observed

Category Label	Absolute Frequency	Relative Frequency (Percent)
Walking-Gleaning	408	36.9
Diving	265	24.0
Fishing, pole-bait	195	17.6
Fishing, rod-reel	41	3.7
Fishing, pole-flies	22	2.0
Throw net fishing	63	5.7
Gill net or trap (weir)	47	4.3
"Paopao" activity	53	4.8
Missing value	50	Missing
Total	1155	100.0

the subsistence fishing activities is presented in more detail in Table 3, which provides the analysis of the relative and adjusted frequencies of participation in these activities as well as the absolute frequencies. Both of these analyses exclude fishing participation in the seasonal "atule" (mackerel) fishery from the large piers in Pago Pago Harbor, as this activity does not constitute a use of the fringing reef.

Reef gleaning, whereby islanders walk the reefs in search of edible echinoderms (certain sea urchins and sea cucumbers), mollusks (especially octopus, clams and turban snails), crustaceans (especially Samoan crabs, lady crabs, spiny lobsters and slipper lobsters) and fishes with a knife, machete, prod or even empty-handed, is the leading fishing activity. Walking and gleaning the reefs received about one third (36.9%) of the fishing effort observed along the fringing reef. Gleaning, as a category of subsistence fishing activity, could be further differentiated into five types of fishing: prodding for octopi in reef holes and under rocks, digging for infaunal clams and sea urchins, gathering sea urchins, gathering edible gastropods and holothurians from the reef's surface by hand and stunning fish with machetes during gleaning activities carried out at night with the light of a lantern or spotlight. If appropriately equipped, a fisherman may participate in all of these activities as the occasion arises, and hence the need of distinguishing each as a separate fishing activity is questionable.

Diving, usually carried out with goggles and homemade spear and sling, constituted the second largest single category of fishing activity. It received about one quarter (24.0%) of the observed fishing effort. Spearfishing is here considered to be two methods of fishing, for while different prey may be sought, the only essential difference in any of the techniques of pursuit is that during the dark hours of the night an artificial light is required, while none is required during the day.

Line fishing, taken as a whole, constituted another one quarter (23.3%) of the fishing effort. If the fishing effort devoted to the "atule" caught from the harbor's piers is included in the total count of fishery participation, line fishing becomes the foremost fishing activity in American Samoa, with 39.3% of the (modified) total. This broad category of subsistence fishing activity included several fishing methods: fishing with a baited-hook and handline, fishing with a baited-hook and a bamboo pole, fishing with a long bamboo pole and feathered flies (trolling)--dragging the flies across the water's surface to catch the seasonally-spawning "gatala" (honeycomb sea bass, mid-May), fishing with a baited-hook and a rod and reel and fishing with a rod and reel and a lured-line. Of these types of line fishing, fishing with a baited-hook and a bamboo pole was the technique most frequently observed, both on the reefs and from the piers (Table 7). All of these techniques except trolling with a long bamboo pole were observed in use along the shore, and all of the techniques were observed in use along the reef margin.

Other methods of subsistence fishing, including techniques using throw nets, gill nets, weirs (=traps) and "paopaos" (outrigger canoes) and the infrequently observed fish drives (=other methods), comprised only 15.8% of the total subsistence fishing activity. All of these techniques require more costly pieces of equipment, a common denominator which suggests an investment versus returns relationship which surpresses the use of these methods of fishing. Lockwood (1971) found a similar pattern in his studies of Western Samoan village economies.

Fishermen

We shall next consider who participates in the subsistence fishery and their relative importance as fishermen. Unfortunately the anthropological record does not provide a firm basis for discerning changes in the relative importance of the fishery's participants according to age and sex, although the development of a substantial job market and a mandatory public education system over the past fifty years may have changed the age and sex structure of the fishery's participants substantially. The importance of such information to an understanding of the socio-economic functioning of a culture is obvious, and its relevance to manpower planning and educational campaigns is considerable.

The information gathered in interviews with numerous fisherman, presented in Table 2, indicates that while some rely heavily upon subsistence activity in providing for themselves and their families, the majority either have salaried positions or, if not yet adults, are students. Most of the fishermen have lived all of their lives in Samoa.

The relative importance of each of eight age-sex groups as participants in the nearshore fishery is shown in Figure 13. Table 4 contains the relative frequencies and adjusted frequencies with which each group was observed actively involved in subsistence fishing. Males (69.9%) fished more than females, in each age-sex group and in the total fishery. Adults (age 21-60, 51.5%) participated most actively in the subsistence fishery, followed by children (age 5-14, 24.8%), adolescents (age 15-20, 19.8%) and elderly Samoans (age 61 and older, 2.6%).

Comparing the observed relative frequency of participation in the fishery with census data which provides an

```
CODE
          I
     1    ******************* (    182)
          I  MALE CHILDREN
          I
          I
     2    ********* (     79)
          I  FEMALE CHILDREN
          I
          I
     3    ***************** (    156)
          I  ADOLES. MALES
          I
          I
     4    ****** (     53)
          I  ADOLES. FEMALES
          I
          I
     5    ************************************** (    374)
          I  ADULT MALES
          I
          I
     6    ****************** (    167)
          I  ADULT FEMALES
          I
          I
     7    ** (     10)
          I  ELDERLY MALES
          I
          I
     8    *** (     17)
          I  ELDERLY FEMALES
          I
          I
     9    ** (     13)
          I  MALE, NON-CHILD
          I
          I
    10    * (      1)
          I  FEMALE, NON-CHILD
          I
          I
    11    *********** (    103)
(MISSING) I  UNDETERMINED
          I
          I.........I.........I.........I.........I.........I
          0        100       200       300       400       500
          FREQUENCY
```

Figure 13. Histogram depicting the frequencies with which members of the different age and sex groups were observed involved in primary subsistence fishery activities

Table 4. Frequencies with which members of the different age and sex groups were observed involved in primary subsistence fishery activities

Category Label	Absolute Frequency	Relative Frequency (Percent)
Male children	182	17.3
Female children	79	7.5
Adolescent males	156	14.8
Adolescent females	53	5.0
Adult males	374	35.6
Adult females	167	15.9
Elderly males	10	1.0
Elderly females	17	1.6
Males, non-child	13	1.2
Females, non-child	1	0.1
Undetermined	103	Missing
Total	1155	100.0

expected occurrence for each age-sex group (U.S. Bureau of Census, 1974), we discover the deviations present in fishing activity. With a value of 1.00 indicating an agreement of actual participation of an age-sex group in the fishery with the expected participation, the deviations are as follows:

1) male children 1.05
2) female children 0.52
3) male adolescents 2.51
4) female adolescents 0.91
5) male adults 1.93
6) female adults 0.82
7) elderly males 0.50
8) elderly females 0.80

This form of analysis, correcting for the pyramidal age structure of American Samoa's rapidly expanding population, indicates that males are more probably involved in the fishery than females and that a Samoan's probability of fishing increases with age into the late teens and the twenties, and then decreases with age into the years of retirement. These changes in the likelihood of participation in the fishery change to a greater degree for males than for females.

It might well be imagined that young Samoans undertaking their primary and secondary education would be absent from subsistence fishery activities. This is only a valid assumption for the hours that they are actually in school. As a rule the teachers in American Samoa assign little homework, the total workload amounting to about an hour's studying per day. A poll of high school students (Table 29) revealed that not one of 91 respondents had been involved in fishing during a "typical weekday" (moderate PM tides). This lack of participation wasn't due to homework or chores, for sports and leisure activities were listed as the chief pasttimes of male students and were among the principal activities of female students. The above consideration of participation by age-sex groups in the fishery and of deviations in the actual participation from the expected demonstrates that during the summer, on weekends and on afternoons and evenings with low tides, the students more than make up for their hours in school.

Interaction of Age-sex Groups with Fishing Activities

To compare the fishery's participants with the various types of fishing activity, a cross-tabulation of age-sex groups by fishing activities is presented in Table 5.

Looking first at the fishing activities (column percentages), several facts stand out. The great majority of the "paopao" activity, spearfishing and the fishing involving nets, rods and reels or bamboo poles equipped with feathered flies is carried out by adolescent males and

Table 5. Crosstabulation of the subsistence fishery participants by the primary subsistence fishery activities

FISHACT

AGESEX	COUNT / ROW PCT / COL PCT / TOT PCT	PAOPAO ACTIVITY 0	WALKING-GLEANING 1	DIVING 2	FISHING, POLE-BA 3	FISHING, POLE-FL 4	FISHING, ROD 5	THROWNET FISHING 6	GILL NET OR TRAP 7	OTHER METHODS 8	ROW TOTAL
1	COUNT	8	63	10	97	1	2	2	9	4	196
MALE CHILDREN	ROW PCT	4.1	32.1	5.1	49.5	0.5	1.0	1.0	4.6	2.0	16.2
	COL PCT	14.8	14.3	3.4	43.3	4.5	4.5	2.9	16.4	36.4	
	TOT PCT	0.7	5.2	0.8	8.0	0.1	0.2	0.2	0.7	0.3	
2	COUNT	2	78	1	11	0	0	0	0	3	95
FEMALE CHILDREN	ROW PCT	2.1	82.1	1.1	11.6	0.0	0.0	0.0	0.0	3.2	7.8
	COL PCT	3.7	17.7	0.3	4.9	0.0	0.0	0.0	0.0	27.3	
	TOT PCT	0.2	6.4	0.1	0.9	0.0	0.0	0.0	0.0	0.2	
3	COUNT	6	30	72	27	6	6	12	20	0	179
ADOLES. MALES	ROW PCT	3.4	16.8	40.2	15.1	3.4	3.4	6.7	11.2	0.0	14.8
	COL PCT	11.1	6.8	24.5	12.1	27.3	13.6	17.4	36.4	0.0	
	TOT PCT	0.5	2.5	5.9	2.2	0.5	0.5	1.0	1.6	0.0	
4	COUNT	0	57	2	8	1	0	0	6	1	75
ADOLES. FEMALES	ROW PCT	0.0	76.0	2.7	10.7	1.3	0.0	0.0	8.0	1.3	6.2
	COL PCT	0.0	13.0	0.7	3.6	4.5	0.0	0.0	10.9	9.1	
	TOT PCT	0.0	4.7	0.2	0.7	0.1	0.0	0.0	0.5	0.1	
5	COUNT	35	37	182	49	14	33	54	16	0	420
ADULT MALES	ROW PCT	8.3	8.8	43.3	11.7	3.3	7.9	12.9	3.8	0.0	34.6
	COL PCT	64.8	8.4	61.9	21.9	63.6	75.0	78.3	29.1	0.0	
	TOT PCT	2.9	3.1	15.0	4.0	1.2	2.7	4.5	1.3	0.0	
6	COUNT	2	153	13	26	0	1	1	4	2	202
ADULT FEMALES	ROW PCT	1.0	75.7	6.4	12.9	0.0	0.5	0.5	2.0	1.0	16.7
	COL PCT	3.7	34.8	4.4	11.6	0.0	2.3	1.4	7.3	18.2	
	TOT PCT	0.2	12.6	1.1	2.1	0.0	0.1	0.1	0.3	0.2	
7	COUNT	1	2	1	5	0	2	0	0	0	11
ELDERLY MALES	ROW PCT	9.1	18.2	9.1	45.5	0.0	18.2	0.0	0.0	0.0	0.9
	COL PCT	1.9	0.5	0.3	2.2	0.0	4.5	0.0	0.0	0.0	
	TOT PCT	0.1	0.2	0.1	0.4	0.0	0.2	0.0	0.0	0.0	
8	COUNT	0	19	0	1	0	0	0	0	1	21
ELDERLY FEMALES	ROW PCT	0.0	90.5	0.0	4.8	0.0	0.0	0.0	0.0	4.8	1.7
	COL PCT	0.0	4.3	0.0	0.4	0.0	0.0	0.0	0.0	9.1	
	TOT PCT	0.0	1.6	0.0	0.1	0.0	0.0	0.0	0.0	0.1	
9	COUNT	0	0	13	0	0	0	0	0	0	13
MALE, NON-CHILD	ROW PCT	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
	COL PCT	0.0	0.0	4.4	0.0	0.0	0.0	0.0	0.0	0.0	
	TOT PCT	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	
10	COUNT	0	1	0	0	0	0	0	0	0	1
FEMALE, NON-CHIL	ROW PCT	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	COL PCT	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	TOT PCT	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
COLUMN TOTAL		54	440	294	224	22	44	69	55	11	1213
		4.5	36.3	24.2	18.5	1.8	3.6	5.7	4.5	0.9	100.0

adult males, though male children were observed to assist significantly in "paopao" and gill net fishing. While these methods differ from traditional techniques, they nonetheless represent the Pacific islanders' concept of "fishing" per se, traditioanlly the work of men (Alexander, 1902; Buck, 1930; Kennedy, 1962; Stair, 1897). The largest portion of the line fishing with a baited-hook, excluding the "atule" fishery, was carried out by male children. Gleaning (not strictly "fishing" to the Samoan), which traditionally was the work of women and children, still appears to be carried out primarily by these groups. The transition of males from "women's work," i.e., gleaning, to "men's work," i.e., "fishing," is apparent during the teenage years of late childhood and early adolescent.

This division of labor along lines of sex and age demonstrates the conservative nature of traditional work patterns and of the cultural ideology which they represent. The technology has changed far more than the work patterns associated with it.

Turning to the particulars of each age-sex group's participation in the fishery (row percentages), the involvement of each group in the different methods of fishing may be discerned in Table 5. The most important type of fishing for females of all ages is gleaning, followed by hook-and-pole fishing. Male children participated most heavily in hook-and-pole fishing, followed by gill net fishing, "pao-pao" activity, gleaning and other types of fishing in which boys served as assistants to older individuals, learning the "Samoan way," by watching and doing. Adolescent males participated most heavily in diving and spearfishing, followed by gleaning, hook-and-pole fishing, gill net fishing and other types of fishing. Adult males also participated most heavily in diving followed by throw net fishing and hook-and-line fishing (usually along the reef margins), and then by other types of fishing.

In addition to providing interesting anthropological information, this analysis of reef use by age-sex groups provides useful information for target groups in educational efforts related to contaminated marine life (ciguatera, coliform bacteria), reef conservation (overfishing) and reef preservation (coral destruction). Clutter (1971), in a special publication of the South Pacific Commission, calls for such educational campaigns as a necessary step in the process of improving marine resource management in Pacific islands.

Since the above analysis of participation in the different types of fishing does not require that a participant be using equipment, a cross-tabulation of integrated age-sex groups by equipment (Table 6) further clarifies the relationship between fishermen and their activities. In

Table 6. Crosstabulation of the age and sex of the participants in the primary subsistence fishery activities by the equipment they were observed using

AGESEX	COUNT / ROW PCT / COL PCT / TOT PCT	FISHLINE BAITED 33	FISHLINE LURED 34	HANDLINE 37	NETS 38	PAOPAO 39	DIVE-SPEARFIS 40	GLEAN-DIVE 41	GLEAN-WALK 42	CONTAINER 44	NONE 45	ROW TOTAL
9 MALE, NON-CHILD	COUNT	24	115	8	50	2	205	3	36	11	14	468
	ROW PCT	5.1	24.6	1.7	10.7	0.4	43.8	0.6	7.7	2.4	3.0	50.2
	COL PCT	22.9	87.8	47.1	94.3	100.0	96.7	10.0	15.9	12.0	21.9	
	TOT PCT	2.6	12.3	0.9	5.4	0.2	22.0	0.3	3.9	1.2	1.5	
10 FEMALE, NON-CHIL	COUNT	19	5	0	2	0	3	24	150	18	9	230
	ROW PCT	8.3	2.2	0.0	0.9	0.0	1.3	10.4	65.2	7.8	3.9	24.7
	COL PCT	18.1	3.8	0.0	3.8	0.0	1.4	80.0	66.1	19.6	14.1	
	TOT PCT	2.0	0.5	0.0	0.2	0.0	0.3	2.6	16.1	1.9	1.0	
15 BOTH SEXES, 5-14	COUNT	62	11	9	1	0	4	3	41	63	41	235
	ROW PCT	26.4	4.7	3.8	0.4	0.0	1.7	1.3	17.4	26.8	17.4	25.2
	COL PCT	59.0	8.4	52.9	1.9	0.0	1.9	10.0	18.1	68.5	64.1	
	TOT PCT	6.6	1.2	1.0	0.1	0.0	0.4	0.3	4.4	6.8	4.4	
COLUMN TOTAL		105	131	17	53	2	212	30	227	92	64	933
		11.3	14.0	1.8	5.7	0.2	22.7	3.2	24.3	9.9	6.9	100.0

keeping with the traditional and contemporary division of labor according to age and sex, male and female children are here regarded as one group, all males of 15 years and older are regarded as one group and all females of 15 years and older are regarded as one group.

In this analysis it become apparent that children frequently participate in fishing equipped only with a bucket, sack or some other container, or with no equipment at all. This illustrates the traditional Samoan educational process whereby children learn by watching and doing. It also implies a "babysitting" aspect for their participation.

The division of fishing labor between adult males and adult females is further confirmed. Women are shown to be primarily equipped for gleaning, either with some sort of probe for use while walking the reef or with goggles and knife for searching waist-deep water for sea urchins. Samoan men are again shown to be the main users of spear-fishing equipment, lured forms of line-fishing equipment and nets.

"Atule" equipment

The frequencies with which different types of fishing equipment were observed in use on the piers is presented in Table 7. Nearly three quarters of the fishing effort is carried out with bamboo poles and baited hooks--simple, inexpensive (bamboo grows locally) and especially

Table 7. Frequencies with which different types of fishing equipment were observed in use in the "atule" fishery of Pago Pago Harbor's piers

Category Label		Absolute Frequency	Relative Frequency (Percent)
Bamboo poles		192	71.4
Rod and reels		36	13.4
Handline		1	0.4
No equipment		40	14.9
Missing value		62	Missing
	Total	331	100.1

appropriate when a multitude of fishermen seek to fish the same area. Throw net fishermen were occasionally observed attempting to cast in the nearby shallows, but in all cases the Samoans using poles scolded these men, causing them to leave, since the splash of their nets scared away the "atule". Throw net fishing, gill net fishing and weir fishing for "atule" were carried out in other areas of the island, forming a significant but unmeasured method of catching the migrating mackerels. Finally, the significant number of unequipped Samoans on the piers indicates the social functions generally in operation in the Samoan approach to work.

Fishing groups

It was observed that the composition of fishing groups differed according to the activities in which they were involved. The mixture of age and sex groups and the size of fishing groups appeared to be somewhat unique for different methods of fishing.

An analysis of fishing groups' sexual composition (mixed versus unmixed) is presented in the cross-tabulation of fishing activities by sexual mixture (Table 8). It is shown that fishing activities carried out by men are carried out by sexually unmixed groups. It is also shown that gleaning, the task of women and children, is equally likely to be carried out in mixed or unmixed groups, a consequence of the participation of both male and famale children in the gleaning. Apparently the traditional social principles which perpetuate sexual task specialization in Samoan society are equally conservative with regards to the intermingling of sexes in the performance of these tasks.

Not surprisingly, an analysis of age mixtures in the fishing groups (Table 9) corresponds with the fishing activities' sex mixtures: activities unmixed in age groups are generally unmixed sexually and activities mixed with regard to age groups are often mixed sexually. These implications are pursued in the analyses of Tables 31-34 (appendix); though they are not believed to be useful to a better understanding of the fishery, they may be of interest to the reader seeking a better understanding of Samoan society.

One characteristic of the fishing groups, their mean number of participants, illuminates historical changes in the fishery. Traditional fishing activities relied heavily upon the co-ordinated efforts of large groups, frequently entire villages, in obtaining the numbers of fish necessary for survival (Buck, 1930; Stair, 1897). Today the average size of fishing groups ranges from 1.2 to 2.3 individuals per group, with the placement and recovery of gill nets being the only exception. These groups sizes are presented from smallest to largest in Table 10 (below).

Table 8. Crosstabulation of the primary subsistence fishery activities by the sex composition of the groups involved in them, indicating whether males and females were mixed in the fishing groups

FISHACT	Count Row pct	SEXMIX Unmixed	Mixed	Row Total
"Paopao" activity		24 92.3	2 7.7	26 2.9
Walking-gleaning		190 50.8	184 49.2	374 41.1
Diving		204 94.9	11 5.1	215 23.7
Fishing, pole-bait		117 73.6	42 26.4	159 17.5
Fishing, pole-fly		8 100.0	0 0.0	8 0.9
Fishing, rod-reel		15 100.0	0 0.0	15 1.7
Throw net fishing		46 97.9	1 2.1	47 5.2
Gill net or trap		40 72.7	15 27.3	55 6.1
Other methods		2 20.0	8 80.0	10 1.1
	Column Total	646 71.1	263 28.9	909 100.0

Table 9. Crosstabulation of the primary subsistence fishery activities by the age composition of the groups involved in them, indicating whether children were present with members of older age groups

FISHACT	Count / Row pct	AGEMIX: Unmixed	Mixed	Row Total
"Paopao" activity		13 52.0	12 48.0	25 2.7
Walking-gleaning		141 37.0	240 63.0	381 41.8
Diving		185 87.3	27 12.7	212 23.2
Fishing, pole-bait		100 62.9	59 37.1	159 17.4
Fishing, pole-fly		6 75.0	2 25.0	8 0.9
Throw net fishing		43 91.5	4 8.5	47 5.2
Gill net or trap		30 54.5	25 45.5	55 6.0
Other methods		7 70.0	3 30.0	10 1.1
	Column Total	539 59.1	373 40.9	912 100.0

Table 10. Mean group sizes for each of the primary subsistence fishery activities of American Samoa

Fishing Activity	Mean Group Size
Fishing, rod-reel	1.2
Fishing, pole-flies	1.3
"Paopao" activity	1.4
Throw net fishing	1.5
Diving	1.8
Fishing, pole-hook (non-"atule")	2.0
Gleaning	2.3
Gill net fishing	3.9

While such quantitative data do not exist for other parts of Oceania, or for earlier periods of history, it is clear that the co-ordinated actions of large groups fishing the nearshore waters cease to play a significant part in the subsistence fisheries of cultures which have adopted the cash economy and the 40-hour work week, as has American Samoa. It is no wonder that the traditional position of "tautai" (fishing chief) has largely vanished in American Samoa, along with the demand for the fishing co-ordination and expertise which the position provided.

Through interviewing the fishermen (Table 2 , II2) I obtained information about their home villages and the relationships existing between the members of fishing groups.

The majority (79.3%) of the subsistence fishing activity in American Samoa is carried out by villagers fishing "their" reefs, i.e., the reefs adjacent to their villages. Samoans have thus continued to treat the reefs adjacent to their villages as "village property," a status assigned to the reefs before the first American military governor declared all submerged lands and reefs to be a part of the public domain (Gray, 1960; Holmes, 1971). The continued identification of reefs as village property suggests that the enforcement aspects of reef management might be constructively, even optimally, assigned to American

Samoa's villages rather than to its police force or its harbor patrol, that is, once such reef management becomes a reality. A new function might be assigned to the revitalized position of "tautai." The policies of reef management formed by the Government of American Samoa, with the counsel of the Department of Marine Resources and a council of village "tautais," could then be enforced by agents with a vested interest in the resources so protected. Such policies of conservation and preservation could be couched in traditional terms, using "kapus" (taboos) as identifiable labels for forbidden fishing seasons and for forbidden catches (juvenile animals, females in berry).

Of those individuals fishing reefs which were not adjacent to their villages, one half (50.0%) were male groups involved in throw net fishing, lured-line fishing or spear-fishing, and about one third (35.5%) were gleaners from the inner Pago Pago Bay, where virtually no reefs exist. Altogether nearly 9% of the observed reef fishermen were residents of the inner bay fishing on the reefs adjacent to villages other than their own. Since roughly 44% of the population of the coast under study lives in this inner bay area (excluding Fagatogo and other villages not along the studied coast but also lacking reefs), it appears that once a village's reef is destroyed, most villagers do without rather than fish another village's reef. This constitutes an impact of reef destruction on a village's subsistence economy and on its marine recreation.

It has been suggested that one direction of change in the Pacific islands has been an increase in the primacy of the nuclear family, as opposed to the "aiga," or extended family (Crocombe,1976). The analysis of relationships within the fishing groups provides one device for evaluating this change, as well as a means of discovering the possible distribution of the fishery's catch. Nuclear family relationships characterized 53.1% of the relationships existing within the fishing groups interviewed, while an additional 29.7% of the relationships were "aiga" ties outside of the immediate family and 17.2% were simply friendships. This information, along with the small size of the fishing groups, tends to support the evolving primacy of the nuclear family and the waning of communal activities in American Samoa, though this trend has far to go before it reaches Western norms. In addition, this analysis revealed that "aiga" relationships characterized 100% of the fishing groups containing both adult males and adult females, a testimony to the protective attitude of Samoan society towards the female.

The above information confirms the importance of the family in the "fa'a Samoa" (the Samoan way of life). It also suggests one approach to establishing an ecological consciousness in Pacific cultures which have generally been evaluated as having none (Clutter, 1971; S.P.C. Technical

Conference, 1962). The idea that "what is good for the reef is good for the family" might prove helpful in establishing environmentally sound attitudes towards conservation and preservation of the coral reefs and the marine life which they harbor.

CHAPTER V

Reef Use:

Interactions of Utilization Patterns and an Environment

The subsistence fishery operates in a number of varied biological and physical environments along the fringing reefs of American Samoa. Fishermen may harvest their catches from any of numerous reef zones, each of which offers a unique combination of challenges and rewards. Changes in the tides, weather and surf conditions also provide obvious reasons for employing different fishing techniques to different degrees in harvesting the nearshore marine life.

The opportunity to study adaptive changes in man's uses of an environment, whereby man seeks to optimize his returns by compensating for changes and differences in the environment from which he is harvesting a resource, is rarely provided in so compact and convenient an area as the coral reef. The subsistence fishery's diversity and adaptability in harvesting a resource from a biologically diverse system could provide a theoretical testing ground for models of resource utilization in cultures where manpower is inexpensive and machinepower is very expensive. The traditional pattern of resource utilization evident in American Samoa's subsistence fishery suggests an optimizing strategy whereby such (manpower) cultures use a variety of harvesting techniques directly proportional to the diversity of the resource system. The conversion of a society to material production based upon fossil fuel-powered industry (machine power) changes the traditional adaptations, simplifying the techniques of resource utilization.

In describing Pacific islanders' responses to differences in biological environments and to changes in physical environments, Kennedy (1962, p. 15) notes that fishing is determined by the tides and the weather, and by personal inclination. The particulars of the environmental influences on each method of fishing were initially determined through interviews (Table 2, II2c).

The primary environmental variables to which subsistence fishermen respond, according to these interviews, are reef zonation, tidal changes and solar periodicity. However, the 40 hour work week which patterns the lives of the plurality of Samoan adults and the 30 hour school week of Samoan children tends to dampen the temporal fishing rhythms.

In describing their responses to zonal differences across the reefs, Samoan fishermen stated that they could use any fishing technique at any location on the reef, if the region is accessible to them.

This accessibility is, of course, determined by the height of the tide. The tidal regime of American Samoa is even and semidiurnal, with a period of approximately 6 hours and 42 minutes (CH2M-Hill, Inc., 1976). While the extreme tidal range observed during the period of this study extended from -0.3 m. (-1.0 ft.) to +1.1 m. (3.8 ft.) (Government of American Samoa, 1975-76), the following data better summarizes the tidal heights for the islands (URS, 1974):

Mean high water:	0.76 m.
Mean tide level:	0.37 m.
Mean low water:	0.00 m.

Samoan fishermen noted that during periods of high water many reef fish move in from deeper water onto the reef platform, and that these can be caught with line fishing techniques and throw nets from shore or by diving anywhere on the reef. Gill nets are also placed at or near reef passes during this period in order to catch reef fish which exit through the "avas" as the tide descends.

During periods of low water, when the fish move into deeper water, fishermen move to these regions too, using line fishing techniques from the exposed reef margins and diving along the reef front and the "avas." Throw net fishermen and reef gleaners move across much of the reef, seeking their catch where they find it but avoiding the high relief thickets of *Acropora*.

Responding to the differences which exist in illumination and in the nature of the activity of marine organisms between day and night, Samoans interviewed stated that while both males and females fish during the day, night fishing is primarily the task of men, though women do participate in the company of male relatives. While the cultural tradition of maintaining a close surveillance of adult females and the strict definition of the woman's role as mother and homemaker provide important reasons for the relative absence of women from night fishing, another reason exists within the marine activity itself. The majority of the sessile marine invertebrates sought as food on the fringing reefs are available during the day; at night gleaners seek more mobile crustacean and fish prey, requiring the cast of a spear or the swing of a machete rather than the hand gathering techniques of day gleaning. The night octopus and gastropods (cowries, cones, augers) may be taken by night gleaners, but these did not appear to be the primary prey of the fishermen.

Other differences which exist between day and night fishing are that artificial light sources are used in gleaning and in diving, and infrequently in line fishing. All three of these techniques are carried out in the same areas of the reef used during the day and they are subject to the same tidal influences. Throw nets are generally not used at night, for the danger of damaging the net and the difficulty of seeing the surface signs of the fish prey increases. On the other hand, gill nets are used, for the fish cannot see the nets.

Fishermen observed that night fishing has greatly diminished since the close of World War II, which, ostensibly, has been the period of American Samoa's economic revolution. Mere Pritchard, a primary informant who graciously gave me several interviews, estimated that only one tenth the fishing activity occurs now as compared with the nights of the late forties. Fia Tiapula, a friend and diving buddy from Aoa village, and one of the islands few commercial nearshore fishermen, explained that he could not interest fellow Samoans in joining him in his profitable pursuit of spiny lobsters and (sleeping) parrot fish because fishing is held in low esteem as work and because the hours are difficult.

In general, however, the weather was found to be of secondary importance in determining reef use patterns by Samoan subsistence fishermen. Since the majority of the fishing effort (Table 13, 87%) is conducted upon the fringing reef or from shore, safe from the effects of weather conditions upon the sea's surface, changes in weather may be discomforting but they are not dangerous to the fishermen. While Samoan fishermen stated their preference for moderate cloud cover and moderate breezes, seeking weather that is "not too hot and not too cold" as one respondent put it, the majority admitted that they would fish as long as the fishing was good--in spite of the weather. Line fishermen would change their bait or lure to compensate for changes in light, or add a weight to combat a strong wind, while gleaners would continue walking the reefs and divers would continue spearfishing in the reef's deeper regions.

This attitude toward changes in the weather is undoubtedly different for tropical fishermen who use large lagoons as fishing grounds, for they must be more concerned with changes in light and consequently in visibility and with changes in wind and rain and consequently in personal safety.

Of greater importance than weather to Samoan fishermen was the size of the ocean swells which pounded the fringing reefs' margins with breakers. Large surf and the resulting surge and wash along the shores were described as dangerous conditions to be avoided by fishermen.

The information gathered in these interviews served to guide the analysis of the quantitative data presented below.

Tidal influence

Because tidal influence was identified as the primary environmental factor governing accessibility to the reef fishing grounds and hence the patterns of fishing activity, it will be considered first. The analysis of tidal data has been adjusted to standardize for the different numbers of road surveys taken during different tidal heights and tidal periods, as described in Chapter II. This adjustment modifies the data presented in Table 3 slightly, though it does not alter the relative importance of the various fishing techniques.

The cross-tabulation of fishery activities by tidal heights (Table 11) and by tidal periods (Table 12) describes the interaction of the changing reef environment and man's adaptive fishing methods. The intensity of fishing on the reef is suppressed by high water, falling off linearly with tidal height and with tidal period (Figure 11). In spite of the different fishing methods available to the fishermen, their ability to harvest marine foods from the fringing reefs is strongly challenged by one meter of sea water. This depth of water on the reef brings with it strong currents as well as the barrier posed by the increased depth itself.

The column percentages listed in these tables indicate the relative importance of each fishing technique for each tidal height and tidal period. The tremendous importance of gleaning during periods of low water is immediately obvious. The significant occurrence of diving and hook-and-pole fishing during low water is also indicated. The increasing importance of these two techniques with increasing water depth over the reef is also evident in the analysis.

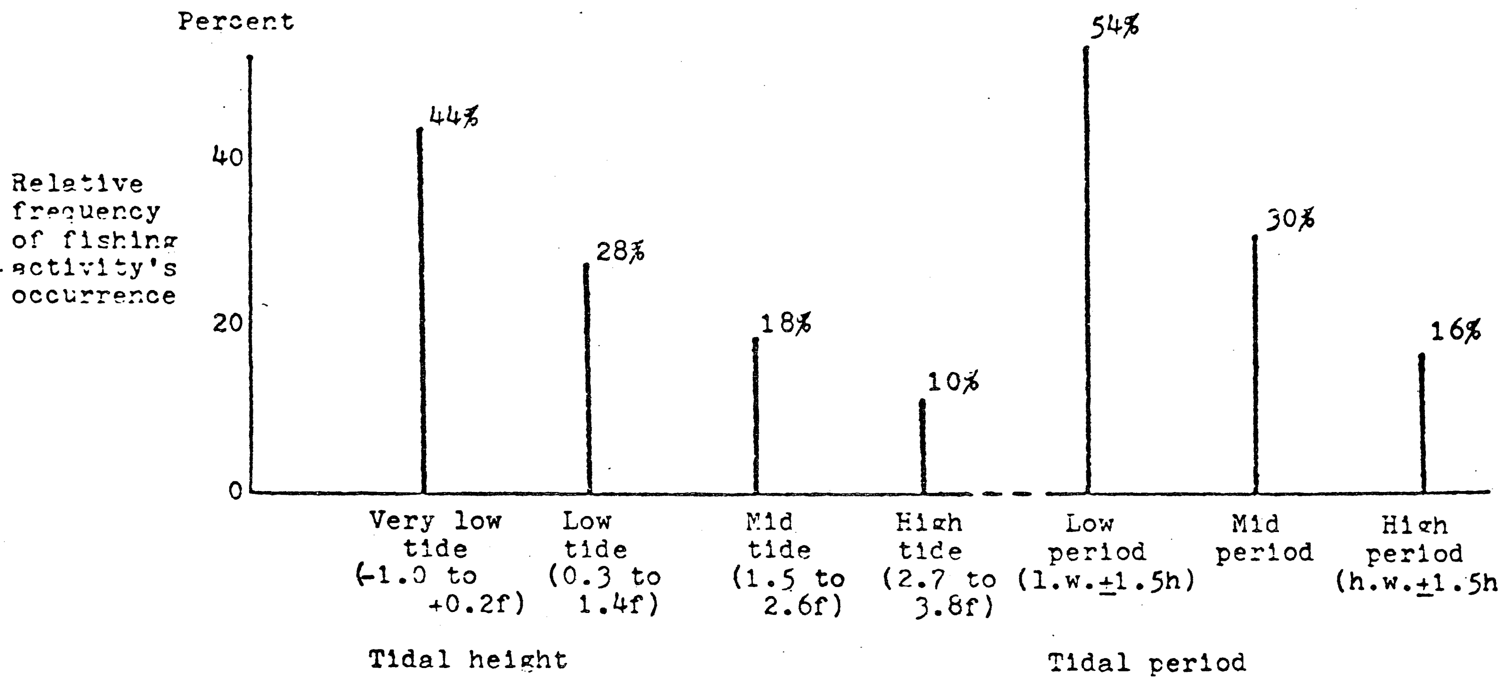
Table 11. Crosstabulation of primary subsistence fishery activities by tidal heights, adjusting counts for the different numbers of road surveys taken during each tidal height

FISHACT (Adj Count / Row Pct / Col Pct)	TIDE: Very low	Low	Mid	High	Row Total
Paopao activity	10.6 20.3 2.4	18.5 35.5 6.7	13.2 25.3 7.4	9.8 18.8 9.7	52.1 5.3
Walking-gleaning	239.4 73.8 55.1	73.9 22.8 26.9	9.6 3.0 5.4	1.4 0.4 1.4	324.3 32.8
Diving	72.2 28.0 16.6	65.1 25.2 23.7	82.8 32.1 46.3	37.8 14.7 37.5	257.9 26.1
Fishing, pole-bait	44.1 23.2 10.1	65.1 34.3 23.7	45.6 24.0 25.5	35.0 18.4 34.7	189.8 19.2
Fishing, pole-flies	12.9 73.3 3.0	3.5 19.9 1.3	1.2 6.8 0.7	0 0 0	17.6 1.8
Fishing, rod-reel	15.2 40.2 3.5	10.6 28.0 3.9	3.6 9.5 2.0	8.4 22.2 8.3	37.8 3.8
Thrownet fishing	27.4 48.5 6.3	12.3 21.8 4.5	8.4 14.9 4.7	8.4 14.9 8.3	56.5 5.7
Gill net or trap	9.9 22.7 2.3	19.4 44.4 7.1	14.4 33.0 8.1	0 0 0	43.7 4.4
Other methods	3.0 32.6 0.7	6.2 67.4 2.3	0 0 0	0 0 0	9.2 0.9
Column Total	434.7 44.0	274.6 27.8	178.8 18.1	100.8 10.1	988.9 100.0%

Table 12. Crosstabulation of primary subsistence fishery activities by tidal periods, adjusting counts for the different numbers of road surveys taken during each tidal period

FISHACT	TIMETIDE Adj Count Row Pct Col Pct	Low Period	Mid Period	High Period	Row Total
Paopao activity		13.4 25.0 2.4	20.8 38.8 6.7	19.4 36.2 11.7	53.6 5.2
Walking-gleaning		307.9 85.5 55.6	50.6 14.1 16.4	1.5 0.4 0.9	360.0 35.0
Diving		94.3 36.8 17.0	94.6 37.0 30.6	67.1 26.2 40.6	256.0 24.9
Fishing, pole-bait		55.2 28.9 10.0	78.9 41.4 25.5	56.6 29.7 34.2	190.7 18.6
Fishing, pole-flies		15.1 78.2 2.8	4.2 21.8 1.4	0 0 0	19.3 1.9
Fishing, rod-reel		18.7 46.1 3.4	10.0 24.6 3.2	11.9 29.3 7.2	40.6 4.0
Thrownet fishing		32.0 54.9 5.8	17.4 29.8 5.6	8.9 15.3 5.4	58.3 5.7
Gill net or trap		11.6 29.1 2.1	28.2 70.9 9.1	0 0 0	39.8 3.9
Other methods		5.3 55.8 0.9	4.2 44.2 1.4	0 0 0	9.5 0.9
	Col Total	553.5 53.8	308.9 30.1	165.4 16.1	1027.8 100.0%

Figure 14. Graphic depiction of the relative occurrence of primary subsistence fishing activity at different tidal heights and tidal periods



The adaptability of diving, line fishing and throw net fishing to changing water depths is indicated by the constancy in their absolute frequency of occurrence throughout the tidal cycle. Diving and line fishing derive their adaptability from their application as subsurface fishing techniques--fishermen using these techniques can harvest deep water during any phase of the tidal cycle by changing the site of their fishing. Throw net fishing derives its adaptability from its application along the land-sea border and in the reef shallows, allowing fishermen to move as the waterline does.

Reef locations of fishing activities

The second important environmental variable governing fishing activity is reef zonation. The relationship between reef zones and locations across the reef has been described in Chapter III. The cross-tabulation of fishing activities by reef locations is presented in Table 13. This analysis is carried further in Tables 32-37 (appendix), in which tidal heights and tidal periods are controlled as third variables. This analysis permits the reader to evaluate the "appropriateness" of each fishing method to each reef location and reef zone.

The similar site responses of Samoan fishermen using line and net techniques attests to the similarity of these fishing methods (pole-and-hook, rod-and-reel, throw net) in seeking subsurface prey from the solid surfaces of shore

Table 13. Crosstabulation of the primary subsistence fishery activities by the reef locations where they were observed

FISHACT	COUNT / ROW PCT / COL PCT / TOT PCT	REEFLOC: SHORE 0	INNER REEF 1	MID REEF 2	OUTER REEF 3	REEF MARGIN 4	AWA-REEF FRONT 5	DEEP WATER 6	ROW TOTAL
0 PADPAD ACTIVITY	COUNT	0	4	3	6	3	17	10	43
	ROW PCT	0.0	9.3	7.0	14.0	7.0	39.5	23.3	3.7
	COL PCT	0.0	2.8	1.1	2.7	1.4	13.4	55.6	
	TOT PCT	0.0	0.3	0.3	0.5	0.3	1.5	0.9	
1 WALKING-GLEANING	COUNT	0	74	163	179	38	1	0	455
	ROW PCT	0.0	16.3	35.8	39.3	6.4	0.2	0.0	39.1
	COL PCT	0.0	51.4	61.7	81.0	17.6	0.8	0.0	
	TOT PCT	0.0	6.4	14.0	15.4	3.3	0.1	0.0	
2 DIVING	COUNT	0	41	71	13	31	109	8	273
	ROW PCT	0.0	15.0	26.0	4.8	11.4	39.9	2.9	23.5
	COL PCT	0.0	28.5	26.9	5.9	14.4	85.8	44.4	
	TOT PCT	0.0	3.5	6.1	1.1	2.7	9.4	0.7	
3 FISHING, POLE-BA	COUNT	136	11	13	2	61	0	0	223
	ROW PCT	61.0	4.9	5.8	0.9	27.4	0.0	0.0	19.2
	COL PCT	78.6	7.6	4.9	0.9	28.2	0.0	0.0	
	TOT PCT	11.7	0.9	1.1	0.2	5.2	0.0	0.0	
4 FISHING, POLE-FL	COUNT	0	0	3	5	11	0	0	19
	ROW PCT	0.0	0.0	15.8	26.3	57.9	0.0	0.0	1.6
	COL PCT	0.0	0.0	1.1	2.3	5.1	0.0	0.0	
	TOT PCT	0.0	0.0	0.3	0.4	0.9	0.0	0.0	
5 FISHING, ROD	COUNT	12	2	6	2	21	0	0	43
	ROW PCT	27.9	4.7	14.0	4.7	46.8	0.0	0.0	3.7
	COL PCT	6.9	1.4	2.3	0.9	9.7	0.0	0.0	
	TOT PCT	1.0	0.2	0.5	0.2	1.8	0.0	0.0	
6 THROWNET FISHING	COUNT	21	3	0	8	21	0	0	53
	ROW PCT	39.6	5.7	0.0	15.1	39.6	0.0	0.0	4.6
	COL PCT	12.1	2.1	0.0	3.6	9.7	0.0	0.0	
	TOT PCT	1.8	0.3	0.0	0.7	1.8	0.0	0.0	
7 GILL NET OR TRAP	COUNT	4	0	3	6	30	0	0	43
	ROW PCT	9.3	0.0	7.0	14.0	69.8	0.0	0.0	3.7
	COL PCT	2.3	0.0	1.1	2.7	13.9	0.0	0.0	
	TOT PCT	0.3	0.0	0.3	0.5	2.6	0.0	0.0	
8 OTHER METHODS	COUNT	0	9	2	0	0	0	0	11
	ROW PCT	0.0	81.8	18.2	0.0	0.0	0.0	0.0	0.9
	COL PCT	0.0	6.3	0.8	0.0	0.0	0.0	0.0	
	TOT PCT	0.0	0.8	0.2	0.0	0.0	0.0	0.0	
COLUMN TOTAL		173	144	264	221	216	127	18	1163
		14.9	12.4	22.7	19.0	18.6	10.9	1.5	100.0

and reef margin. The fishermen using these techniques may be observed to respond similarly to changes in water levels if one follows them through the tidal cycle. The relatively greater use of baited lines from shore and during high water and of lines trolling lures or feathered flies along the outer reef's seaward margin and during low water is also indicated in this analysis, suggesting that the fish sought on the inner reef (foraging goat fishes and snappers) obtain their food in a different manner than the deep-water fish (sea basses and jacks); this, of course, is correct.

Spearfishermen seek their catch in the bathymetrically varied zones on the reef, for the shelter offered in these regions assures the presence of the fish they pursue. The level algal flats offer no such shelter and do not harbor resident communities of reef fish, hence divers do not frequent the outer reef. The relationship between bathymetric irregularity and spearfishing pressure suggests that the population sizes of reef fishes inhabiting the different zones on the reef are directly related to their bathymetric variations, for this relationship between these variables describes a rank order correspondence as follows:

	Bathymetric variation	Spearfishing pressure
(Maximum)	1. Reef front	1. Reef front (40%)
	2. Mid reef	2. Mid reef (26%)
	3. Inner reef	3. Inner reef (15%)
	4. Reef margin	4. Reef margin (11%)
(Minimum)	5. Outer reef	5. Outer reef (5%)

Samoans gleaning the reefs during low tide concentrate their efforts on the outer and mid sections of the fringing reefs. In these regions the edible shelled mollusks and the octopus are most likely to be found, as well as edible echinoderms which are generally distributed across the entire reef. Hence the gleaners are rewarded to a greater degree on the outer reef than on other sections of the reef, and a larger portion of their walking search of the reef's surface is focused here. The same wave action and surface irregularities which impeded my surveys of the reef margin probably depress the gleaning of this area over the course of the year.

The "paopao" activity comprises line fishing, diving and gill net fishing, and hence is more difficult to analyze than the above techniques of fishing. In general "paopaos" used in conjunction with line fishing were observed along the reef margin and above the reef slope; this was especially true of the submerged reef sill on the Aua reef, where the majority of the "paopao" activity occurred. During the night "paopaos" were frequently seen used in conjunction with diving on the inner and mid reef, serving as a floating platform for a suspended light and as a container for the catch. "Paopaos" used in gill net fishing were frequently observed stationed on the outer reef during the placement and retrieval of the nets.

The incidence of gill net or trap (=weir) fishing across the reef attests to the importance of the reef passes to these fishing techniques, for they were observed primarily on the outer reef and reef margin. (The observation of four Samoans involved in rolling up a gill net on shore, presented in Table 15, should have been categorized as "in transit.")

While the interaction of fishing activity, reef zones and tidal cycles could be pursued further, it is believed that the patterns characterizing this interaction have been established above. Readers may use Tables 32-37 to continue this consideration.

Tidal influence on reef locations

In order to clearly discern the influence of tidal heights and tidal periods on the use of locations across the reef by fishermen, a cross-tabulation of these three variables was conducted. Tables 14 and 15 present these cross-tabulations.

Table 14. Crosstabulation of reef locations of primary subsistence fishery activities by tidal heights, adjusting for the different numbers of surveys taken during each tidal height

REEFLOC (Adj Count / Row Pct / Col Pct)	TIDE: Very low	Low	Mid	High	Row Total
Shore	20.5 12.6 5.1	48.4 29.8 19.3	52.8 32.5 32.6	40.6 25.0 45.3	162.3 18.0
Inner reef	31.9 30.2 8.0	45.8 43.3 18.3	16.8 15.9 10.4	11.2 10.6 12.5	105.7 11.7
Mid reef	91.2 44.6 22.9	62.5 30.6 24.9	39.6 19.4 24.4	11.2 5.5 12.5	204.5 22.7
Outer reef	120.1 80.7 30.1	14.1 9.5 5.6	13.2 8.9 8.1	1.4 0.9 1.6	148.8 16.5
Reef margin	95.0 58.4 23.8	46.6 28.7 18.6	16.8 10.3 10.4	4.2 2.6 4.7	162.6 18.0
Ava-reef front	37.2 35.6 9.3	24.6 23.6 9.8	21.6 20.7 13.3	21.0 20.1 23.4	104.4 11.6
Deep water	3.0 23.1 0.8	8.8 67.7 3.5	1.2 9.2 0.7	0 0 0	13.0 1.4
Col Total	398.9 44.3	250.8 27.8	162.0 18.0	89.6 9.9	901.3 100.0%

Table 15. Crosstabulation of the reef locations of primary subsistence fishery activities by tidal periods, adjusting for the different numbers of surveys taken during each tidal period

REEFLOC	TIMETIDE Adj Count Row Pct Col Pct	Low Period	Mid Period	High Period	Row Total
Shore		24.0 15.3 4.7	73.0 46.6 26.3	59.6 38.1 40.0	156.6 16.7
Inner reef		40.9 38.5 8.0	49.0 46.1 17.6	16.4 15.4 11.0	106.3 11.3
Mid reef		134.4 62.4 26.3	49.8 23.1 17.9	31.3 14.5 21.0	215.5 23.0
Outer reef		144.2 86.8 28.2	17.4 10.5 6.3	4.5 2.7 3.0	166.1 17.7
Reef margin		114.8 66.4 22.5	50.6 29.3 18.2	7.5 4.3 5.0	172.9 18.4
Ava-reef front		46.3 43.0 9.1	31.5 29.3 11.3	29.8 27.7 20.0	107.6 11.5
Deep water		6.2 48.4 1.2	6.6 51.6 2.4	0 0 0	12.8 1.4
	Col Total	510.8 54.5	277.9 29.6	149.1 15.9	937.8 100.0%

Since this analysis corrects for the uneven distribution of surveys among the different tidal heights and tidal periods, it is possible to estimate the importance of each region of the reef to the subsistence fishery by comparing the relative use of each reef location by fishermen. Though fishing activity is not the only indicator of a reef location's value to the fishery, the near-equality of the catch per unit effort for the major fishing techniques of gleaning, line fishing and diving (Chapter VI) lends validity to its use here. Recognizing that shore fishing harvests the inner reef and that fishing on the reef margin may harvest the outer reef, if gleaning, diving or net fishing techniques are in use, or the reef front, if line fishing techniques are used, it is necessary to modify the data presented in Tables 14 and 15 somewhat. Combining shore fishing with the activity on the inner reef and dividing up the reef margin activity according to the information in Table 13, the relative importance of the regions of the reef to the fishery is as follows:

Inner reef	29%
Mid reef	23%
Outer reef	26%
Reef front	22%

The relative use of these regions is doubtlessly the result of their accessibility, which decreases with distance from shore and with depth, and their productivity, which (generally) increases towards the reef's seaward margin.

The above analysis of the fishery's use of the regions across the reef indicates that substantially different "use-values" do not exist for the inner, mid and outer reef and the reef front. It would therefore not be justifiable for planners or engineers to choose between regions of the reef based on their value to the subsistence fishery. On the other hand, reef zones with considerable rubble and little live coral cover appeared (from direct observation) to receive less fishing activity than did bathmetrically-varied coral platforms and thickets which harbor resident populations of marine life on the reefs. This in-region differentiation is substantiated above.

The shoreward shift of fishing activity with the rising tide and the seaward shift of fishing activity with the falling tide is apparent in the column percentages of Tables 14-15. Contrariwise, the tidal changes of fishing pressure in each region may be discerned by surveying the row percentages in these tables; the relatively greater responsiveness of fishing on the midreef, outer reef and reef margin to tidal changes is clear in such a survey.

Longshore differences in fishing activity

Having considered the differences which exist in the subsistence fishing across the fringing reef, it is appropriate to next consider differences in the fishing activity occurring along the coast. Since the coast under study consists of approximately equal lengths of exposed sea coast (Faga'itua to Breaker's Point, 7.8 km.) and of sheltered bay coast (Breaker's Point to Malaloa, 7.6 km.), an excellent opportunity exists to assess the effects of the environmental conditions differing between the two types of coast on the fishery. In addition, the bay coast consists of roughly equal lengths of landfilled reef (Atuu to Malaloa, 3.5 km.) and of reef which, though dredged and filled in some sections, has been spared the degradation of the inner bay (Breaker's Point to Leloaloa, 4.1 km.). This characteristic affords the opportunity to assess the effect of landfill operations and of water quality deterioration on the subsistence fishery.

The frequencies with which fishing activity was observed adjacent to villages along the coastline under study are presented in Table 20. The cumulative relative frequencies of fishing activity along the sea coast (47.7%) and along the bay coast (52.3%) are nearly equal, but this equality is misleading. Indeed, the majority of the fishing activity exerted within the bay occurs along the

Table 16. Frequencies with which villages along the coast under study were adjacent to the primary subsistence fishery activities

Category Label	Absolute Frequency	Relative Frequency (Percent)
Faga'itua	146	13.0
Amaua	90	8.0
Auto	57	5.1
Avaio	25	2.2
Alega	46	4.1
Pyramid Rock (landmark)	30	2.7
Aumi	32	2.8
Lauli'ituai	31	2.8
Lauli'ifou	79	7.0
Tafananai-Anasosopo	55	4.9
Aua	305	27.2
Lepua	66	5.9
Leloaloa	100	8.9
Atuu	24	2.1
Satala-Siufaga	4	0.4
Pago Pago	34	3.0
Total	1155	100.1

unfilled portion of the bay (89% of the total fishing activity observed along the bay coast under study, excluding "atule"). The effect of landfill operations upon the subsistence fishery is indicated by the greatly reduced fishing pressure in the nearshore waters adjacent to the inner bay villages of Atuu, Satal-Siufaga, Pago Pago, Autapini (0) and Malaloa (0).

The relative use of the nearshore waters adjacent to the three types of coastline by the subsistence fishery, as indicated by the absolute frequency of their use by fishermen during 134 road surveys, is as follow:

	Absolute frequency/km.
Open sea coast	68.7 fishermen/km.
Unfilled (outer) bay coast	128.3 fishermen/km.
Filled (inner) bay coast	17.7 fishermen/km.

These frequencies of reef use per unit length may be utilized as a measure of the value of the reef to the subsistence fishery, as long as it is remembered that this value system is based upon use and not upon production.

The intensity of the fishing pressure exerted upon the outer bay's reef is nearly twice that of the open sea's reef, probably because of the greater population densities within the bay area. This doubtlessly leads to more overfishing on the reefs in the "urban" portion of Tutuila than occurs along the open sea coast--a phenomenon characteristic of urban centers in islands across the Pacific (Clutter, 1971).

The different amounts of fishing activity observed along filled and unfilled portions of the bay are even more substantial, for the landfilled inner bay receives only one-seventh the fishing activity per unit length that the outer bay experiences. This is not even equal to the portion of the fishing activity which would be applied on a healthy reef using line fishing techniques from the shore and reef margin (Table 13). It speaks strongly to the loss experienced by adjacent villages, both in terms of the fishery's catch and its recreational benefits, when the fringing reefs are filled. As has been shown above (Chapter IV), villagers generally do not move their fishing activities to another village's reef when their reef is lost, for the traditional identification of these areas as "village property" is still viable in the "fa'a Samoa," or Samoan way of life.

Table 17, cross-tabulating the coastline by the fishing methods used in the nearshore waters adjacent it, provides insight into the qualitative and quantitative differences in the types of fishing activities applied to the two reef regimes. The bay fishery includes a relatively greater portion of "paopao" activity and of line and throw net fishing, while the sea coast fishery emphasizes gleaning and gill net fishing to a relatively greater degree.

Table 17. Crosstabulation of the adjacent shoreline by the primary subsistence fishery activities

VILLSITE	FISHACT: COUNT / ROW PCT / COL PCT / TOT PCT	PACPAO ACTIVITY 0	WALKING-GLEANING 1	DIVING 2	FISHING. POLE-BA 3	FISHING. POLE-FL 4	FISHING. ROD 5	THROWNET FISHING 6	GILL NET OR TRAP 7	OTHER METHODS 8	ROW TOTAL
23 OPEN SEA'S SHORE	COUNT	15	254	144	29	9	11	23	33	9	527
	ROW PCT	2.8	48.2	27.3	5.5	1.7	2.1	4.4	6.3	1.7	47.6
	COL PCT	28.3	62.3	54.1	14.9	40.9	26.8	36.5	70.2	81.8	
	TOT PCT	1.4	23.0	13.0	2.6	0.8	1.0	2.1	3.0	0.8	
24 PAGO BAY'S SHORE	COUNT	38	154	122	166	13	30	40	14	2	579
	ROW PCT	6.6	26.6	21.1	28.7	2.2	5.2	6.9	2.4	0.3	52.4
	COL PCT	71.7	37.7	45.9	85.1	59.1	73.2	63.5	29.8	18.2	
	TOT PCT	3.4	13.9	11.0	15.0	1.2	2.7	3.6	1.3	0.2	
COLUMN TOTAL		53	408	266	195	22	41	63	47	11	1106
		4.8	36.9	24.1	17.6	2.0	3.7	5.7	4.2	1.0	100.0

A similar cross-tabulation of the subsistence fishing activity for the sea coast and bay coast by its location on regions across the reef is presented an Table 18. This analysis indicates the greater importance of shore fishing within the bay (25.4%) and of reef platform fishing along the open sea coast (mid reef, 26.8%; outer reef, 23.0%). This is the result of the presence of suitable line fishing grounds, especially the Aua sand flats bordering Lalolamauta Stream and its associated mangrove swamp, the dredged lagoon of upper Aua village and the deep water accessible from the landfilled shoreline of the inner bay, within Pago Pago Bay. On the other hand, the broad, coral-rich reefs of the open sea coast invite a different pattern of reef utilization, with regards both to fishing methods and to the location of their application.

Considering the differences in reef structure and benthos, in exposure to waves and wind and in fishing activity which exist between the two coasts, it is not surprising that there is a greater sensitivity in the fishing along the sea coast to the tidal cycle. This sensitivity is revealed in the analysis presented in Table 19, where the amount of fishing activity is shown to vary 700% over the tidal cycle for the sea coast, in contrast to less than 300% along the bay coast.

Table 18. Crosstabulation of the adjacent shoreline by the locations of the primary subsistence fishery activities on the reef

VILLSITE	COUNT / ROW PCT / COL PCT / TOT PCT	SHORE 0	INNER REEF 1	MID REEF 2	OUTER REEF 3	REEF MARGIN 4	AWA-REEF FRONT 5	DEEP WATER 6	ROW TOTAL
OPEN SEA'S SHORE	23	18	70	126	108	93	43	12	470
		3.8	14.9	26.8	23.0	19.8	9.1	2.6	46.5
		11.6	60.3	54.3	58.1	47.4	39.1	80.0	
		1.8	6.9	12.5	10.7	9.2	4.3	1.2	
PAGO BAY'S SHORE	24	137	46	106	78	103	67	3	540
		25.4	8.5	19.6	14.4	19.1	12.4	0.6	53.5
		88.4	39.7	45.7	41.9	52.6	60.9	20.0	
		13.6	4.6	10.5	7.7	10.2	6.6	0.3	
	COLUMN TOTAL	155	116	232	186	196	110	15	1010
		15.3	11.5	23.0	18.4	19.4	10.9	1.5	100.0

Table 19. Crosstabulation of the shoreline adjacent to primary subsistence fishery activities by tidal height, adjusting counts for the different numbers of surveys taken during each tidal height

VILLSITE (Adj Count / Row Pct / Col Pct)	TIDE: Very low	Low	Mid	High	Row Total
Open Sea's Shore	238.6 53.5 54.5	106.4 23.8 39.9	72.0 16.1 39.0	30.8 6.9 30.6	447.8 45.2
Pago Bay's Shore	199.1 36.7 45.5	160.2 29.6 60.1	112.8 20.8 61.0	70.0 12.9 69.4	542.1 54.8
Col Total	437.7 44.2	266.6 26.9	184.8 18.7	100.8 10.2	989.9 100.0%

The general pattern of interaction suggested by the above analyses of the reef environment and the subsistence fishery is relatively simple. The nature of a biological community--in this case a coral reef--is determined by the physical conditions of that environment. The community thus established, in turn, alters some of these physical conditions in its development of a climax community. The resulting bio-physical environment then influences the nature of the methods used to harvest its resources, and the timing and location of their application.

Subsistence fishing on three villages' reefs

How the environment determines which fishing technique is used when and where is further clarified by considering the uses of the three surveyed reefs by the subsistence fishery.

When fishing activities carried out on Faga'itua reef are cross-tabulated with their sites of utilization in Table 20, the importance of gleaning and diving to this open sea reef become obvious. Weir and gill net fishing on the outer margin of the large "ava" and "paopao" use in the deeper waters on and off the reef also constitute significant methods of fishing. Line fishing and throw net fishing, on the other hand, are not important at Faga'itua because of the irregular, coral-rich bottom, and because of the reef's exposure to moderate surf and onshore tradewinds.

Table 20. Crosstabulation of the primary subsistence fishery activities by their observed locations on the reef for the village of Faga'itua

FISHACT	REEFLOC: COUNT / ROW PCT / COL PCT / TOT PCT	SHORE 0.	INNER REEF 1.	MID REEF 2.	OUTER REEF 3.	REEF MARGIN 4.	AWA-REEF FRONT 5.	DEEP WATER 6.	ROW TOTAL
0. PAOPAO ACTIVITY	COUNT	0	0	1	2	0	3	5	11
	ROW PCT	0.0	0.0	9.1	18.2	0.0	27.3	45.5	8.6
	COL PCT	0.0	0.0	2.2	9.5	0.0	27.3	71.4	
	TOT PCT	0.0	0.0	0.8	1.6	0.0	2.3	3.9	
1. WALKING-GLEANING	COUNT	0	22	29	13	3	0	0	67
	ROW PCT	0.0	32.8	43.3	19.4	4.5	0.0	0.0	52.3
	COL PCT	0.0	88.0	64.4	61.9	16.7	0.0	0.0	
	TOT PCT	0.0	17.2	22.7	10.2	2.3	0.0	0.0	
2. DIVING	COUNT	0	3	15	0	1	8	2	29
	ROW PCT	0.0	10.3	51.7	0.0	3.4	27.6	6.9	22.7
	COL PCT	0.0	12.0	33.3	0.0	5.6	72.7	28.6	
	TOT PCT	0.0	2.3	11.7	0.0	0.8	6.3	1.6	
3. FISHING, POLE-BA	COUNT	1	0	0	0	1	0	0	2
	ROW PCT	50.0	0.0	0.0	0.0	50.0	0.0	0.0	1.6
	COL PCT	100.0	0.0	0.0	0.0	5.6	0.0	0.0	
	TOT PCT	0.8	0.0	0.0	0.0	0.8	0.0	0.0	
4. FISHING, POLE-FL	COUNT	0	0	0	2	1	0	0	3
	ROW PCT	0.0	0.0	0.0	66.7	33.3	0.0	0.0	2.3
	COL PCT	0.0	0.0	0.0	9.5	5.6	0.0	0.0	
	TOT PCT	0.0	0.0	0.0	1.6	0.8	0.0	0.0	
6. THROWNET FISHING	COUNT	0	0	0	0	3	0	0	3
	ROW PCT	0.0	0.0	0.0	0.0	100.0	0.0	0.0	2.3
	COL PCT	0.0	0.0	0.0	0.0	16.7	0.0	0.0	
	TOT PCT	0.0	0.0	0.0	0.0	2.3	0.0	0.0	
7. GILL NET OR TRAP	COUNT	0	0	0	4	9	0	0	13
	ROW PCT	0.0	0.0	0.0	30.8	69.2	0.0	0.0	10.2
	COL PCT	0.0	0.0	0.0	19.0	50.0	0.0	0.0	
	TOT PCT	0.0	0.0	0.0	3.1	7.0	0.0	0.0	
COLUMN TOTAL		1	25	45	21	18	11	7	128
		0.8	19.5	35.2	16.4	14.1	8.6	5.5	100.0

The importance of the coral platforms and thickets of the mid reef (35.2%) and of the algal flats and Porolithon ridge of the outer reef (30.5%) to the fishing activity on the Faga'itua reef is also emphasized in this analysis.

Describing the interactions of different fishing techniques with different reef locations requires information on particular features of the Faga'itua reef as well. For instance, this reef harbors especially large populations of the short-spined urchin, "tuitui," in its inner and mid reef regions. The presence of this delicious source of food draws considerable attention from gleaners who might otherwise concentrate more heavily upon the outer reef. The existence of a large, deep "ava" and of a healthy mid reef Acropora thicket encourages diving and "paopao" activity in both of these areas, day and night. The seaward margin consists of a relatively high and unbroken Porolithon ridge exposed to southeasterly swells and tradewinds, thus discouraging fishermen from using fishing lines or throw nets in this region of the reef. Consequently, most line fishing occurs along the inner reaches of the "ava" during low tides.

The fishing activities carried out on Lauli'ifou reef are cross-tabulated with the sites of their use in Table 21. Again the importance of gleaning and diving to the villages along the open sea coast is emphasized, for together these fishing techniques account for almost 90% of the fishing on the Lauli'ifou reef. Yet in considering the absolute frequencies of fishing activity, it is apparent that all fishing activity is suppressed on the reef, and that gleaning and diving are the only fishing methods out of nine groups which are of any consequence in the utilization of the reef.

At Lauli'ifou the fishing on the reef increases from shore to sea, rising from 9.9% of the total on the inner reef to 29.6% on the mid reef to 46.5% on the outer reef and its margin.

Distinctive characteristics of the Lauli'ifou reef include its exposure to severe wave and wind action, for this reef generally experiences the largest breakers along the coast under study and is known for the dangerous currents which consequently sweep across it and out its "ava." These conditions present difficulties to the fishermen using the reef platform and dangers to those using its margins. An analysis of the tidal influence upon the fishing activity at Lauli'ifou indicated that 65.8% of all fishing here was conducted during very low tides, as compared with 44.0% for the entire coast under study.

Also important to an understanding of the activity at Lauli'ifou is the filling of sections of the inner reef

Table 21 . Crosstabulation of the primary subsistence fishery activities by their observed locations on the reef for the village of Lauli'ifou

FISHACT	REEFLOC COUNT ROW PCT COL PCT TOT PCT	INNER REEF 1.	MID REEF 2.	OUTER REEF 3.	REEF MARGIN 4.	AWA-REEF FRONT 5.	DEEP WATER 6.	ROW TOTAL
1. WALKING-GLEANING	COUNT	1	14	20	3	0	0	38
	ROW PCT	2.6	36.8	52.6	7.9	0.0	0.0	53.5
	COL PCT	14.3	66.7	83.3	33.3	0.0	0.0	
	TOT PCT	1.4	19.7	26.2	4.2	0.0	0.0	
2. DIVING	COUNT	3	7	4	1	8	2	25
	ROW PCT	12.0	28.0	16.0	4.0	32.0	8.0	35.2
	COL PCT	42.9	33.3	16.7	11.1	100.0	100.0	
	TOT PCT	4.2	9.9	5.6	1.4	11.3	2.8	
3. FISHING, POLE-BA	COUNT	2	0	0	4	0	0	6
	ROW PCT	33.3	0.0	0.0	66.7	0.0	0.0	8.5
	COL PCT	28.6	0.0	0.0	44.4	0.0	0.0	
	TOT PCT	2.8	0.0	0.0	5.6	0.0	0.0	
4. FISHING, POLE-FL	COUNT	0	0	0	1	0	0	1
	ROW PCT	0.0	0.0	0.0	100.0	0.0	0.0	1.4
	COL PCT	0.0	0.0	0.0	11.1	0.0	0.0	
	TOT PCT	0.0	0.0	0.0	1.4	0.0	0.0	
5. FISHING, ROD	COUNT	1	0	0	0	0	0	1
	ROW PCT	100.0	0.0	0.0	0.0	0.0	0.0	1.4
	COL PCT	14.3	0.0	0.0	0.0	0.0	0.0	
	TOT PCT	1.4	0.0	0.0	0.0	0.0	0.0	
COLUMN TOTAL		7	21	24	9	8	2	71
		9.9	29.6	33.8	12.7	11.3	2.8	100.0

as a roadbed, an alteration which place the reef's Acropora thicket adjacent to an elevated rocky shore. Since such thickets are unsuitable to line fishing, net fishing and gleaning, all of these activities are suppressed through the loss of the original inner reef.

Aua reef's fishing activities are cross-tabulated with the sites of their application in Table 22. In this analysis the increased importance of line fishing relative to gleaning and diving, and the occurrence of net fishing, "paopao" activity and other fishing methods (=fish drives) are apparent.

The increase in subsistence fishing along the shore, the reef margin and the reef front produces a more even distribution of fishing pressure across the reef. In the heavily populated bay area the "value" of the reef as a source of food and recreation increases and this value is distributed across the entire reef rather evenly (32%, 22%, 30%, 16% for inner, mid, outer and frontal reefs respectively).

Aua reef contains a number of distinctive features not found on either of the above sea coast reefs. As a bay reef it is largely sheltered from large seas and surf, and hence line and net fishermen, divers and fishermen using "paopaos" frequent its reef margin and reef front much more frequently they do at Faga'itua or Lauli'ifou.

Table 22. Crosstabulation of the primary subsistence fishery activities by their observed locations on the reef for the village of Aua

FISHACT	REEFLOC COUNT ROW PCT COL PCT TOT PCT	ISHORE 0.	INNER REEF 1.	MID REEF 2.	OUTER REEF 3.	REEF MARGIN 4.	AWA-REEF FRONT 5.	DEEP WATER 6.	ROW TOTAL
0. PAOPAO ACTIVITY	COUNT	0	4	2	4	3	10	3	26
	ROW PCT	0.0	15.4	7.7	15.4	11.5	38.5	11.5	9.6
	COL PCT	0.0	15.4	3.4	10.5	7.0	24.4	100.0	
	TOT PCT	0.0	1.5	0.7	1.5	1.1	3.7	1.1	
1. WALKING-GLEANING	COUNT	0	8	32	27	7	1	0	75
	ROW PCT	0.0	10.7	42.7	36.0	9.3	1.3	0.0	27.7
	COL PCT	0.0	30.8	54.2	71.1	16.3	2.4	0.0	
	TOT PCT	0.0	3.0	11.8	10.0	2.6	0.4	0.0	
2. DIVING	COUNT	0	9	13	2	1	30	0	55
	ROW PCT	0.0	16.4	23.6	3.6	1.8	54.5	0.0	20.3
	COL PCT	0.0	34.6	22.0	5.3	2.3	73.2	0.0	
	TOT PCT	0.0	3.3	4.8	0.7	0.4	11.1	0.0	
3. FISHING, POLE-BA	COUNT	54	4	3	1	17	0	0	79
	ROW PCT	68.4	5.1	3.8	1.3	21.5	0.0	0.0	29.2
	COL PCT	88.5	15.4	5.1	2.6	39.5	0.0	0.0	
	TOT PCT	19.9	1.5	1.1	0.4	6.3	0.0	0.0	
4. FISHING, POLE-FL	COUNT	0	0	3	2	1	0	0	6
	ROW PCT	0.0	0.0	50.0	33.3	16.7	0.0	0.0	2.2
	COL PCT	0.0	0.0	5.1	5.3	2.3	0.0	0.0	
	TOT PCT	0.0	0.0	1.1	0.7	0.4	0.0	0.0	
5. FISHING, ROD	COUNT	3	0	1	1	8	0	0	13
	ROW PCT	23.1	0.0	7.7	7.7	61.5	0.0	0.0	4.8
	COL PCT	4.9	0.0	1.7	2.6	18.6	0.0	0.0	
	TOT PCT	1.1	0.0	0.4	0.4	3.0	0.0	0.0	
6. THROWNET FISHING	COUNT	4	1	0	1	4	0	0	10
	ROW PCT	40.0	10.0	0.0	10.0	40.0	0.0	0.0	3.7
	COL PCT	6.6	3.8	0.0	2.6	9.3	0.0	0.0	
	TOT PCT	1.5	0.4	0.0	0.4	1.5	0.0	0.0	
7. GILL NET OR TRAP	COUNT	0	0	3	0	2	0	0	5
	ROW PCT	0.0	0.0	60.0	0.0	40.0	0.0	0.0	1.8
	COL PCT	0.0	0.0	5.1	0.0	4.7	0.0	0.0	
	TOT PCT	0.0	0.0	1.1	0.0	0.7	0.0	0.0	
8. OTHER METHODS	COUNT	0	0	2	0	0	0	0	2
	ROW PCT	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.7
	COL PCT	0.0	0.0	3.4	0.0	0.0	0.0	0.0	
	TOT PCT	0.0	0.0	0.7	0.0	0.0	0.0	0.0	
COLUMN TOTAL		61	26	59	38	43	41	3	271
		22.5	9.6	21.8	14.0	15.9	15.1	1.1	100.0

The dredging of a portion of the Aua reef has formed a relatively deep lagoon, with a bottom of calcareous sand and mud, fished from shore by line fishermen. This dredging, on the other hand, has made this area unavailable to gleaners and divers, for its depth and lack of coral cover have eliminated the species sought by these fishermen. The extensive sand flats provide an excellent area for using throw nets in the capture of mullet and other schooling fish which frequent such environments. Finally, the submerged reef sill lying off of these sand flats is an area of heavy "paopao" activity, in which lines are used to catch fish and octopus (traditional cowrie lure technique).

Conclusion

This study certainly bears out Kennedy's (1962, p. 15) observation that fishing is determined by tides, the weather and by personal inclination. Yet by considering the interactions of the fishery and its varied environment the particulars of these interactions have been defined. In addition, numerous applications to reef management have been suggested, including an evaluative scheme which demonstrates the importance of all regions of the fringing reefs adjacent to villages to the subsistence fishery.

CHAPTER VI

The Fishery's Catch, Its Uses and Its Distribution

The economy of American Samoa may be characterized as a mixed economy, using Fisk's (1964) definition of the term, for it includes both market and subsistence sectors within its fabric. During the past several decades the market sector has come to play the dominant role in supplying the material needs of American Samoans. In fact, the territory has been described as having essentially a U.S.-linked economy funded primarily by federal aid and by family remittances (Wolfe Management Services, 1969). The importance of the subsistence sector has diminished to the point that considerable quantities of the traditional Samoan staple, taro, are imported from neighboring Western Samoa, while an abundance of arable land remains untilled in American Samoa (Wolfe Management Services, 1969). The reduced importance of subsistence production in the islands' fishery follows the pattern of agriculture, for the marine catch no longer supports local needs (CH2M-Hill, Inc., 1976; Manar, 1969).

American Samoa's nearshore food resources have been neglected since the loss of the Samoans' traditional forms of reef management in the early twentieth century. The resulting lack of management and the steady increase in population in the islands produced the extremely overfished condition of the reefs noted by S.P.C. Fisheries Officer H. Van Pel in his 1954 survey of the Samoan Islands. After studying the fringing reefs and the subsistence fishery, Van Pel stated that it would be useless to improve the fishing gear used in the reef areas, for they were already overfished, with fish caught elsewhere in the Pacific at lengths of 12" being taken in the Samoas at 4-5". He estimated that the total catch for Tutu'ila was less than 100 tons per year.

Such levels of production do not appear significant when distributed over a population of 30,000 Samoans. On the other hand, if this distribution of the fishery's catch was uneven, with some families relying heavily upon subsistence production and other families relying entirely upon the market economy, then the value of the subsistence fishery, overfished or not, might warrant intelligent management instead of dismissing neglect.

While the economy as a whole may no longer be characterized as a subsistence economy, the nearshore fisheries are certainly sources of food for the families of the fishermen involved in harvesting their reefs. Interviews of Samoan fishermen (Table 23, II3a-g) indicated that almost all of their catches are consumed by the fishermen's "aiga", or extended families. This was particularly true

Table 23. A sample of the short interview form used on-site, showing its questions and the information gained from the compiled answers

I. The questions: A Sample Questionnaire (compacted)

Interview #:

Date:
Time:
Location:

1. Subject (s):
   a. Sex(es):
   b. Age(s):
   c. Relationships:
   d. Home village(s):
   e. Do they occupy the same domicile?
2. Fishery activity (ies):
   a. Reef harvesting:
   b. Time involved today:
   c. Time involved weekly:
   d. Equipment in use:
   e. Other information:
3. Catch data:
   a. Use or distribution of catch:
   b. Composition, number, size and fishing technique:

II. The answers: A Compilation of Information Useful to This Study (N of questionnaires=79)

	1.	Personal and interpersonal information:	
N=29	a.	Sex confirmation of road evaluation:	100%
N=29	b.	Age confirmation of road evaluation:	96.6%
N=27	c.	Group confirmation of road evaluation:	96.3%
N=145	d.	In-group "aiga" relationships:	82.8%
N=21	e.	In-group "aiga" relationships in groups with a mixture of adult males and adult females:	100%
N=145	f.	In-group immediate-family relationships:	53.1%
N=150	g.	Villagers of adjacent village: Of those fisherpeople not from the village adjacent to their activity, 50% were male groups involved in fishing with a thrownet or with rod and reel or in diving, and 35.5% were reef gleaners from villages without reefs	79.3%

2. Primary subsistence fishery activities:

N=76 a. Gleaning

Average time/day=	1.7 hrs.
Average days/week=	2.4 days
Average time/week=	4.1 hrs.

Equipment: short, unpronged spears
large kitchen knives
crowbars
machetes

N=13 b. Line fishing (non-pier)

Average time/day=	1.7 hrs.
Average days/week=	3.4 days
Average time/week=	5.8 hrs.

Equipment: bamboo poles, approx. 2-4 meters
rod and reels
manufactured hooks, flies and lures

N=34 c. Diving

Average time/day=	1.8 hrs.
Average days/week=	2.1 days
Average time/week=	3.8 hrs.

Equipment: 2-eyed goggles or masks
sling-shot sling
short, unpronged spears

N=17 d. Throw net fishing

Average time/day=	2.2 hrs.
Average days/week=	3.1 days
Average time/week=	6.8 hrs.

Equipment: manufactured circular throw nets

N=6 e. Gill net fishing

Average days/week=	4.7 days

Equipment: manufactured gill nets

3. Catch data:

a. Gleaning (day): 100% home consumption, excepting shells

Mollusks (edible)	1.3 lbs./hr.
octopus, "fe'e", <u>Polypus</u>	(0.8 lbs./hr.)
turbans, "alili", <u>Turbo</u>	(0.4 lbs./hr.)
giant clams, "faisua", <u>Tridacna</u>	
clams, "pipi", <u>Gafrarium</u>	
limpets, "matapisu", Patellidae	
Mollusks (jewelry)	0.2 lbs./hr.
money cowrie, "pule", <u>Cypraea</u>	(0.2 lbs./hr.)
other cowries, cones and augers	
Echinoderms	0.5 lbs./hr.
short-spined urchin, "tuitui", <u>Echinometra</u>	
sea cucumber, "loli", <u>Holothuria</u>	
sea cucumber, "sea", <u>Holothuria</u>	
long-spined urchins, "vana", <u>Diadema</u> and <u>Echinothrix</u>	

b. Gleaning (night): 100% home consumption, excepting shells

Fishes — 0.6 lbs./hr.

squirrel fishes, "malau", _Myripristis_ and _Holocentrus_
sea basses, "gatala", _Epinephelus_
snappers, "ta'iva", _Lutjanus_; "savane", _Lutjanus_; "mu", _Monotaxis_
goat fishes, "afulu", _Mulloidichthys_; "vete", _Upeneus_
surgeon fishes, "alogo", _Acanthurus_
moray eels, "pusi", _Gymnothorax_

Mollusks — 0.2 lbs./hr.

night octopus, "fe'e po", _Polypus_
cowries, conches, augers, miters and cones

Crustaceans — 0.4 lbs./hr.

spiny lobster, "ulatai", _Panulirus_
slipper lobster, "ula", _Scyllarides_
Samoan crabs, "pa'a", _Carpilius_ and _Scylla_

c. Line fishing (non-pier): 100% home consumption

Fishes — 1.1 lbs./hr.

sea basses, "gatala", _Epinephelus_
squirrel fishes, "malau", _Myripristis_ and _Holocentrus_
snappers, "ta'iva", _Lutjanus_
emperors, "'awa'awa", _Lethrinus_; "maka ele ele", _Lethrinus_
jacks, "lupo", _Caranx_; "malauli", _Caranx_; "ulua", _Caranx_
goat fishes, "fuga", _Parupeneus_; "savane", _Upeneus_; "afulu", _Mulloidichthys_

d. Line fishing (pier): home consumption and market

Fishes — 1.3 lbs./hr.

mackerel, "atule", _Trachurops_; "atule", _Selar_; "opelu", _Decapterus_ — (1.3 lbs./hr.)
jacks, "lupo", _Caranx_; "malauli", _Caranx_; "ulua", _Caranx_

e. Diving: 92% home consumption (biased in market's favor)

Fishes — 1.0 lbs./hr.

parrot fishes, "fuga usi", _Scarus_; "lae'a", _Scarus_; "ufa", _Scarus_
surgeon fishes, "pone", _Ctenochaetus_; "manini", _Acanthurus_; "palani", _Acanthurus_; "siusina", _Acanthurus_; "maono", _Zebrasoma_; "ume", _Naso_; "alogo", _Acanthurus_

sea basses, "gatala", Epinephelus
moray eels, "pusi", Gymnothorax
halfbeaks, "ise", Hypothamphus
squirrel fishes, "malau", Myripristis and Holocentrus
butterfly fishes, angel fishes, box fishes and wrasses

Crustaceans (night only:)
spiny lobster, "ulatai", Panulirus
slipper lobster, "ula", Scyllarides
Samoan crabs, "pa'a", Carpilius and Scylla

Mollusks 0.3 lbs./hr.
octopus, "fe'e", Polypus (0.3 lbs./hr.)
cowries, augers, miters, cones, and conches

f. Throw net fishing: 88% home consumption

Fishes per manhour: 5.5 lbs./hr.
per throw net hour: 8.3 lbs./hr.
mullets, "fuafua" and "agae", Mugil and Crenimugil
mackerels, "atule", Trachurops; "atule", Selar; "opelu", Decapterus
sardines, "pelupelu", Harengula; "pelupelu", Harengula
surgeon fishes, "manini", Acanthurus
halfbeaks, "ise", Hyporhamphus

g. Gill net fishing: 100% home consumption

Fishes 5.3 lbs./night
squirrel fishes, "malau", Myripristis and Holocentrus; "manifinifi", Myripristis
surgeon fishes, "pone", Acanthurus; "fuga", Callyodon;
wrasses, "sugale", Thalassoma; "sugale", Hemipteronotus; "lalafi", Cheilinus
goat fishes, "matalau", Pseudepeneus "afulu", Mulloidichthys
sea basses, "gatala", Epinephelus
snappers, "mu", Monotaxis

of the catch harvested through gleaning, diving, line fishing (other than "atule") and gill net/weir fishing, for which subsistence uses monopolized the catches (100%). Only the catches of the productive throw net fishermen and of line fishermen harvesting "atule" entered the market system, though not to a large extent. It is no wonder that questioned fishermen responded that the priorities for their catches' use were first "family foods," second "gifts of love" (traditional reciprocity) and (a distant) third "sell in the market."

The quantities of seafoods distributed through the market sector could not be estimated because the appropriate records are not kept by the island's markets and the estimates of fishermen appeared unreliable. In addition, a major portion of the catch which does enter the market sector is vended along the road, particularly in Fagatogo and Nuu'uli, where Samoan children frequently sell the strings of fish and bags of cooked turbans and clams which their families have caught and prepared.

Interviews with Tutuila's market management (Table 24) revealed that the nearshore fishery's small scale surpluses, particularly from the "atule" fishery, are channeled into the Star of the Sea Fish Market. This government-initiated fish market sells less than two tons of mackerel, herring, mullet, lobsters and octopi per year, along with much

Table 24. Summary of the market use of nearshore marine life through institutional markets

(All information below was provided by supply managers relying upon their memories, for records of this nature were not kept by any of the Samoan businesses.)

Business	Reference	Marine Life Marketed
Star of the Sea Fish Market	Pat Scanlan	(primarily offshore fishes) mackerels: 2000 lbs./yr. sardines: 200 lbs./yr. mullets: 400 lbs./yr. lobsters: 500 lbs./yr. octopus: 500 lbs./yr.
Burns Philps (market)	Martin Farrow	no local seafoods sold
Toko's Market	Ben Pakalani	(offshore fishes only: 7800 lbs./yr.)
Village Market	Charles Ho Ching	(offshore fishes only: 26000 lbs./yr.)
G.H.C. Reid (market)	Gene Reid	(offshore fishes only: no estimate)
Soli's Restaurant	Soli Laolagi	octopus: 800 lbs./yr.
Rainmaker Hotel	Tony Brown	no local seafoods sold

larger quantities of offshore fish caught by the island's small commercial fleet. One restaurant manager estimated that his business used about 800 pounds of octopus, bought from members of his "aiga" in Aua and in the Manu'a Islands, in the preparation of a traditional Samoan "fia fia" feast. Using Van Pel's estimate of 100 tons per year, it seems that roughly 3% of the nearshore catch is channeled into the established markets in American Samoa.

The nearshore fisheries do not, then, provide significant amounts of cash income to the majority of American Samoans. It is more likely that a small number of Samoan families supplement their family budgets by directing their surplus catch into the island's markets, and that these fishermen are the most active fishermen using the reefs. When such individuals were interviewed, they generally described their profession as fisherman-farmer.

Instead, the subsistence fishery plays a more substantial role in saving money by providing protein in the Samoan diet. Cook (1976), in his research in French Polynesia, and Smith (1947), in his studies of Micronesia, found that the subsistence fisheries of other island groups in the Pacific provided their native populations with the major portion of their protein. While even this is not true in American Samoa today, the information gathered in the interviews with fishermen (Table 23, II2-3) suggests that the "average" gleaner (2.2 kg/wk), diver (2.2 kg/wk) and line fisherman (2.9 kg/wk) provide enough seafood each week to meet their own protein needs for five to six days or for a family of five for one day. Since the average household size in American Samoa is 4.7 (G.A.S., 1975), one fisherman per family would provide that family's protein for one meal per week by fishing for four to five hours during the course of the week.

A questionnaire polling high school students about their daily lives is summarized in Table 25, providing additional information about the use of nearshore marine life in the American Samoan diet. This poll indicates that reef life constitutes a small portion of the animal protein consumed by the average Samoan family. While the islands' local starches, taro, breadfruit and cooking bananas, continue to form the foundation of the Samoan diet, corned beef, chicken, spam and canned fish are now the islanders' primary animal proteins.

Only on Sunday, when the traditional weekly feast prepared in the "umu" (earthen oven) is served, were reef foods listed as <u>a part</u>--one of approximately three animal protein foods--of their meal by a substantial portion of the respondents (36%, versus 9% on weekdays). Combining these probabilities for the week (6x9% + 1x36% = 90%), it appears likely that an average family in American Samoa eats some reef-derived food once a week as a part of their dinner.

Table 25. A summary of information about the daily lives of the Samoan people, drawn from questionnaires completed by students of Faga'itua High School

I. The questions: A Sample Questionnaire (compacted)

1. How many people live in your household-unit?
2. At what time did you wake up?
3. What were your activities before breakfast?
4. What did your family eat for breakfast?
5. What were your activities after school yesterday?
6. What did your family eat for supper last night?
7. What were your activities after supper?
8. At what time did you go to bed?

II. The answers: A Compilation of Information Useful to This Study (N of questionnaires=91)

1. Average family size: 8.7 people/household unit

2. Average waking time: 6:05 A.M.

3. Pre-breakfast activities:

	Males	Females
Grooming	21%	28%
Leisure	47%	17%
Sports	12%	6%
Housework	2%	47%
Yardwork	2%	11%
Animal tending	9%	0
Plantation work	4%	0
Cooking	7%	4%
School work	16%	15%
*Fishing activities	0	0

4. Breakfast's composition

	Weekday
No breakfast	8%
Tea, coffee or cocoa	5%
T/C/C and toast	38%
T/C/C, toast and eggs	18%
T/C/C, toast, eggs and either juice or milk	7%
T/C/C and pancakes	2%
T/C/C and sandwich	6%
T/C/C, Samoan starch and canned meat	9%
Cereal	5%
*T/C/C, toast and "palolo"	2%
Other	2%

5. Post-school activities:

	Males	Females
Leisure	19%	30%
Sports	50%	23%
Housework	0	36%
Yardwork	2%	17%
Animal tending	10%	0
Plantation	15%	0
Cooking	14%	21%
School work	0	13%
*Swimming	5%	2%
*Fishing activities	0	0
Other	4%	21%

6. Supper's composition

	Weekday	Sunday
Chicken	84%	91%
Beef	91%	85%
Pork	19%	24%
Spam	56%	30%
Lamb	16%	9%
Canned fish (tuna, wahoo, mackerel, pilchard, sardine)	25%	33%
Fresh fish (agae, gatala, malauli, alogo, poge, manini, atule, tifitifi, sugale, ume, sumu)	9%	36%
Other seafoods		
Crab	0	3%
Octopus	0	3%
Average number of protein dishes per respondent	3.3	3.5
Starches		
Banana	52%	
Breadfruit	39%	
Taro	36%	
Rice	21%	
Canned spagetti	11%	
Potatoes	7%	
Bread	65%	
Other foods		
Soups	9%	
Chop suey	4%	
Cooked vegetables	9%	
Salads	3%	
Canned fruit	1%	

7. Post-supper activities

	Males	Females
Leisure		
Television	28%	22%
Socializing (bingo, etc)	33%	20%
School work	75%	69%
House work	0	11%
Choir practice	0	9%
Village meeting	6%	0

8. Average bedding time: 10:15 P.M.

What types of marine life constitute the catch of the subsistence fishermen and what is the relative importance of each? While a rough idea of what local seafoods are served on the Samoan table may be obtained from the above poll, the study of the catches taken in each type of fishing activity provides better information on the reef life used as food in the islands (Table 23, II3).

Qualitatively, the marine animals sought as food by fishermen in American Samoa are those used thusly across the tropical Pacific. Parrot fishes, surgeon fishes, soldier and squirrel fishes, goat fishes, sea basses, snappers, mullet, mackerel, octopi, clams, marine snails, limpets, sea urchins (in berry), sea cucumbers, lobsters, shrimps and crabs--these groups of animals and certain edible seaweeds (rare in Samoa) represent the primary food resources of the coral reefs. While the species vary in their importance among the Pacific islands, the genera are uniform in their distribution, belonging to the broad Indo-Malaysian zoogeographical zone (Randall, 1953), and occur throughout most of tropical Polynesia and Micronesia. A large portion of the fauna is used as human food, providing a variety in catch which is in keeping with the coral reef's biotic diversity (Banner and Randall, 1952; Catala, 1957; Harry, 1953; Hiatt, 1950).

Even with the generalized fishing techniques in use today, no single method captures all of the types of marine life available on the reef. The hands and a probe are used in gleaning and diving to seek out sessile invertebrates, while hook-and-line, spear-and-sling and nets are used to catch fin fishes. Thus the composition of the catch varies among the fishermen using different methods.

In gleaning the reef during the day Samoan fishermen harvest about 0.8 kg. (1.8 lbs.) of edible mollusks and echinoderms per hour of fishing effort, of which approximately 60% is body weight, and an additional 0.1 kg (0.2 lbs.) of cowries intended for use in making jewelry. This catch is composed primarily of octopus ("fe'e," _Polypus_, o.8 lbs.), with turbans ("alili," _Turbo_), giant clams ("faisua," _Tridacna_), money cowries ("pule," _Cypraea_), sea cucumbers ("loli" and "sea," _Holothuria_), short-spined urchins ("tuitui," _Echinometra_) and long-spined urchins ("vana," _Diadema_ and _Echinothrix_) completing most of the remainder. Since so much of the catch is made up of invertebrates with heavy exoskeletons, rough field measurements and appropriate references (Kay and Magruder, 1977; Richard, 1977) were used to convert the total catch per unit effort for the edible invertebrates from 0.8 kg. to 0.5 kg. (1.2 lbs.) body weight per hour.

In gleaning the reef during the night Samoan fishermen harvest about 0.5 kg. (1.2 lbs.) of fish, crustaceans and mollusks per hour of active fishing effort. The catch of fishes (0.6 lbs.) includes chiefly squirrel fishes (Myripristis and Holocentrus), sea basses (Epinephelus), snappers (Lutjanus and Monotaxis), goat fishes (Mulloidicthys and Upeneus) and surgeon fishes (Acanthurus). The crustacean portion of the catch (0.4 lbs.) consisted primarily of spiny lobsters ("ulatai," Panulirus), slipper lobsters ("ula," Scyllarides) and xanthid crabs ("kuku pa'a," Carpilius and Scylla). Lastly, night fishermen walking the reefs with spear or machete generally pick up the colorful reef gastropods and the night octopus ("fe'e po," Polypus), and these mollusks make up the third portion of their catch (0.2 lbs.).

In line fishing from the shore and from the reef edge Samoan fishermen harvest about 0.5 kg. (1.1 lbs.) of fin fish per hour of fishing effort. Their catch is composed primarily of sea basses (Epinephelus), squirrel fishes (Lutjanus), emperors (Lethrinus), jacks (Caranx) and goat fishes (Upeneus, Parupeneus and Mulloidichthys). While the fishing catch taken by line fishermen differed between reef margin and shore and between day and night, it was not felt that the sample sizes allowed for adequately differentiating these catches.

Somewhat surprisingly, the estimated average catch per unit effort of 0.6 kg. (1.3 lbs.) per hour for Samoans fishing for the seasonal "atule" (mackerel) did not exceed the above-mentioned CPUE* for line fishermen harvesting fin fish from the fringing reef by a significant amount. "Atule" fisherman using the harbor piers caught an average of 0.5 kg. (1.1 lbs.) of mackerel per hour of fishing effort during the season's "slow" periods and an average of 0.6 kg. (1.4 lbs.) during its "fast" periods. The entire range in CPUE, averaged for groups over periods of 20 minutes, extended from to 0.1 to 3.3 kilograms of "atule" per man per hour. The reaction of Samoan fishermen to fluctuations in the numbers of mackerel in the bay appeared to follow the classical entrance curve of economic theory, for as the numbers of mackerel caught increased, so did the number of Samoans fishing for them. This reaction, which might well triple to quintuple the amount of fishing activity in a given area, tended to depress the individual fisherman's catch from what it might otherwise have been, though the total catch of mackerel increased substantially. The pier fishery's catch included some jacks (Caranx), taken with lured lines, as well as the mackerels (Trachurops, Selar and (Decapterus), taken with baited and feather-lured lines.

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*CPUE = Catch per unit effort

In spearfishing Samoan divers harvest about 0.6 kg. (1.3 lbs.) of fish and mollusks per hour of fishing effort. This catch is supplemented by an additional catch of crustaceans during the night, though my data does not permit an estimate of this weight. The catch of fish consists of parrot fishes (Scarus), surgeon fishes (Acanthurus, Ctenochaetus, Zebrasoma, and Naso), sea basses (Epinephelus), moray eels (Gymnothorax), halfbeaks (Hyporhamphus), squirrel fishes (Myripristis and Holocentrus) and other reef fishes. The catch of mollusks follows the composition of that listed above for gleaning, through the size of the catch is considerably smaller (0.3 lbs./hr.).

Throw net fishing is the most productive method of fishing used on the fringing reef, with an average CPUE of 3.8 kg. (8.3 lbs.) for each throw net fisherman hour. This CPUE falls to 2.5 kg. (5.5 lbs.) per hour of fishing effort when the fishermen are assisted by other men spotting schools of fish from higher positions. The catch is composed of the schooling fishes, particularly mullet (Mugil and Crenimugil), mackerel (Trachurops, Selar and Decapterus), sardines (Harengula), halfbeaks (Hyporhamphus), and surgeon fish (Acanthurus).

Finally, gill net fishing was found to yield a catch of 2.4 kg. (5.3 lbs.) per retrieval. Since the gill nets are generally set and retrieved during the daylight periods of high water and left overnight to catch fish leaving the fringing reefs as the tide falls, the catch per retrieval could be standardized to catch per manhour. Thus modified the CPUE for gill net fishing is 0.6 kg. (1.3 lbs.) per "fishing" hour, and the catch consists of squirrel fishes (Myripristis and Holocentrus), surgeon fishes (Acanthurus and Callydon), wrasses (Thalassoma, Hemipteronotus and Cheilinus), goat fishes (Pseudepeneus and Mulloidichthys), sea basses (Epinephelus) and snappers (Monotaxis).

This analysis reveals an amazing uniformity in the catch per unit effort for gleaning, diving, line fishing and gill net fishing, all of which average about 0.5 to 0.6 kg./hr. Only throw net fishing differs significantly from this CPUE, yielding catches of 2.5 kg./hr.; this highly skilled form of fishing produces four to five times the catch per unit effort that other forms of subsistence fishing yield.

These estimates of CPUE are substantially lower than those given by Smith (1947) for Micronesian atolls, where divers caught from 2 to 11 kg. of fish per hour. They are more comparable to those recorded by Lockwood (1971) in Western Samoa, where yields averaged about one kilogram of fish per hour for fishing off of the reef fronts. These low yields per unit effort confirm the overfished nature of American Samoa's fringing reef, previously indicated by the small sizes of the individual fish caught. Unfortunately, uniform and reliable CPUE data of a comparable nature is not available for other reef fisheries.

While the majority of the fish on and around coral reefs are quite small, 90% or more being less than 0.1 kg. in size (Stevenson and Marshall, 1974), those fish taken in American Samoa's nearshore fishery are generally less than half this size. As has been shown by Randall (1963) and others, the catch returns per unit effort decrease under the intense fishing pressure which produces such overfished conditions; these conditions are frequently associated with rapid expansion of island populations and with urbanization (Clutter, 1971). Such socio-economic change certainly characterizes American Samoa.

Having estimated the CPUE for the different methods of subsistence fishing and having the data available to estimate the numbers of Samoans involved in the daytime fishery along the coastal section under study (especially Tables 35-37), I estimated the yearly catch for each fishing activity and for the nearshore fishery between Faga'itua and Malaloa (15.4 km.). The total catch for these fringing reefs, estimated as covering about two square kilometers, is 22524 kgs./yr., of which 65% is fish and 35% is invertebrates. An additional 9734 kgs. of "atule" (mackerel) was caught on the piers of this coast during the year, described by all fishermen as an exceptional season (Table 26).

Table 26. Yearly catch estimates for the daylight subsistence fishery activities along a coastal section (15.4 km.) of Tutuila Island, American Samoa

Subsistence fishing activity	Fisherman hours/day	Fisherman hours/year	Catch/hour (lbs. body wt.)	Catch/year (lbs. and kgs.) for 203 ha. of fringing reef
Gleaning	37.9	11824.8	Mollusks 1.0 Echinoderms 0.2	11825 lbs.=5375 kgs. 2365 lbs.=1075 kgs.
Diving	32.2	10046.4	Fish 1.0 Mollusks 0.3	10046 lbs.=4566 kgs. 3014 lbs.=1370 kgs.
Line fishing	31.4	9809.3	Fish 1.1	10790 lbs.=4905 kgs.
Throw net	4.3	1341.6	Fish 5.5	7379 lbs.=3354 kgs.
Gill net/weir	(2.5 hauls)	(780 hauls)	Fish(/haul) 5.3	4134 lbs.=1879 kgs.
Total reef platform catch			Fish (65%) Invertebrates (35%) Total	14704 kgs. 7820 kgs. 22524 kgs.
"Atule" fishery (piers)	211.2	16473.6	Fish 1.3	21416 lbs.=9734 kgs.

The analysis of the annual catch of the five primary groups of subsistence fishing activities (line fishing techniques combined as one and "paopao" activity distributed among line fishing, diving and gill net fishing) indicates that their relative importance, in terms of production is similar to that suggested by the numbers of Samoans participating in each. This follows from the rough equality in the CPUE for fishermen participating in gleaning, diving and line fishing; naturally the high CPUE of net fishing techniques improves their relative standing substantially. The distribution of the catch between these fishing activities, excluding the seasonal "atule," is as follows:

1) Gleaning 28.6%
2) Diving 26.4%
3) Line fishing 21.8%
4) Throw net fishing 13.1%
5) Gill net fishing 10.2%

When the "atule" catch, which is considerably larger than the catches of any of these reef platform fishing activities, is introduced into this assessment of the relative importance of fishing techniques as forms of production, line fishing stands as the largest contributor to the nearshore fishey's catch for the coastal section under study. This introduction must be taken with some reservation, for much of American Samoa does not have the access to migrating schools of mackerel which the bay area does.

The analysis in Table 26 permits us to calculate the yields per unit area for the subsistence fisheries harvesting these fringing reefs. The estimated reef area, from shore to the seaward boundary of the reef slope, is 203 hectares. The daylight fishery's catch is 22524 kgs. per year. In-village studies and a small number of road surveys carried out at night suggest that the night fishing activity is no more than one-tenth of the day fishing, and consists of gleaning, diving and line fishing, with a probable annual catch of about 1729 kg. The total catch, then, of the reef fishery is 24253 kgs./yr., indicating an annual yield of 119 kgs./ha.--approximately 12 M.T./km.^{2}/yr.

When compared with other tropical fisheries data this yield for American Samoa's nearshore subsistence fishery may strike the reader as too large. Stevenson and Marshall (1974, p. 153-4) list harvests of selected bottom fisheries ranging from 0.4 to 4.7 M.T./km.^{2}/yr. for the Caribbean Sea and ranging from 0.4 to 5.1 M.T./km.^{2}/yr. for three Pacific atolls; the average annual yield per unit area for the eleven bottom fisheries considered by these researchers is two metric tons per square kilometer per year. Munro (1974, p.20), considering fisheries in the Caribbean, concludes that rates of porduction of shelf-dwelling demersal fishes approaching 1.8 M.T./km.^{2}/yr. are attained under unregulated but intensive fishing.

The yield per unit area for the overfished reefs in American Samoa is roughly six times as large as these average yields for tropical demersal fisheries. This increased productivity is the result of the diversity of the subsistence fishery's catch, which includes a large portion of invertebrates (35%) as well as many fish species too small to be harvested by commercial fishing operations. In addition, the fisheries considered by Stevenson and Marshall and by Munro harvest their catch from deep reefs and lagoons, which Harry (1953) has observed are much less productive than shallow reefs lying under several meters of sea water.

American Samoa's highly productive fringing reefs are nonetheless underproductive--due to overfishing. The failure to develop and implement management practices for reef conservation and preservation in the face of intense socio-economic change has allowed the degradation of the reefs and the depletion of their stocks of marine life. In spite of the difficulties involved, the subsistence fishery's production could be enhanced by placing the appropriate controls on fishing pressures and by applying such controls in an effective manner.

As has been suggested by other reef fishery scientists (Clutter, 1971; Johannes, 1973), effective management of reef resources is more likely to occur when the right to fish an area is controlled by those in tenurial positions, as opposed to the open-access to the "Commons" of Western traditions. When the rights to use a resource are limited to and controlled by those holding such rights, the principle of (enlightened) self-interest tends to prevent overexploitation. In the Pacific such principles of reef tenure have the added value of having existed for millenia; they are therefore familiar and acceptable.

In American Samoa such fishing rights would be appropriately vested in the villages adjacent to the fringing reefs, as was discussed in Chapter IV. These villages already have viable forms of social and political organization in their "fonos" (council of titles family heads) and their "pule nu'u" (quasi-mayor, a Western-initiated position). This traditional structure of control could be usefully involved in forming and implementing reef management practices and policies.

Employing an existing structure in a new way, i.e., in reef conservation and preservation, would be inexpensive too. This is in keeping with the productive value of the nearshore fishery, whose total annual catch probably lies between 55 and 75 metric tons (body wt.), plus shells.

CHAPTER VII

Summary

Reef zonation was described and related to subsistence fishing activity. Certain generalizations were forthcoming. 1) Reef gleaners harvest the flat to moderately irregular areas characterized as the *Porolithon* ridge of the reef margin, the coralline algal flats of the outer reef and the platforms of *Porites*, *Pavona* and *Psammocora* on the mid and inner reef. 2) Divers spearfish the moderately to highly irregular reef slope, margin and *Acropora* thickets. 3) Line fishermen use several subsurface techniques in fishing the reef slope and "avas" (ravines) from adjacent shallow areas. 4) Throw net fishermen cast their nets over flat areas of the inner reef and reef margin. 5) Gill nets and weirs are set in reef passes on the outer reef and reef margin. Together these five groups of primary subsistence fishing techniques harvest the major zones existing on the fringing reef.

The relative frequency of occurrence of techniques used in the nearshore fishery was assessed. These are as follows: gleaning, 33%, diving, 26%, line fishing, 25%, throw net fishing, 6%, gill net or weir fishing, 4%, and "paopao" activity and other methods, 6%.

The relative importance of members of age-sex groups as participants in the nearshore fishery was assessed, revealing males to conduct all fishing activities except gleaning, traditionally the work of women and children, and line fishing with bamboo poles and baited hooks. The distribution of fishing activity within the reef fishery, according to age-sex groups, was as follows: adult males, 36%, male children, 17%, adult females, 16%, adolescent meales, 15%, female children, 8%, adolescent females, 5%, elderly females, 2%, elderly males, 1%, and unclassified fishermen, 1%.

The relative importance of the regions across the fringing reef to the fishery in terms of their relative use was assessed, and found to be generally uniform across the reef platform. The distribution of fishing activity according to the location of its occurrence was as follows: inner reef, 29%, mid reef, 23%, outer reef, 26%, and reef front, 22%.

The analysis of longshore differences in the nature and location of the fishing activity in Pago Pago Bay and on the open sea coast revealed important differences in both. The open sea reefs receive more gleaning and spear-fishing, while the reefs within the bay receive a proportionally higher share of the line fishing. More of the fishing activity along the sea reefs is focused on the mid and outer reef, while the distribution of the fishing pressure on the bay reefs is more uniform.

Further consideration of differences existing in the fishing activity along stretches of Tutuila's coast indicated that regions of landfilled reef in the inner bay receive only one-seventh of the fishing effort applied to nearby unfilled reef.

The sensitivity of nearshore fishing activity to environmental variables was considered. The fishing activity was found to be strongly responsive to the tidal and diurnal cycles, and relatively unresponsive to changes in the weather.

The catch per unit effort for each of the primary subsistence fishing activities was calculated. These CPUE's are: throw net fishing, 2.5 kg./hr., gill net fishing, 0.6 kg./hr. (or 2.4 kg./haul), diving, 0.6 kg./hr., gleaning, 0.5 kg./hr., and line fishing, 0.5 kg./hr. The CPUE for fishermen harvesting the migrating schools of "atule," using line fishing techniques from the harbor piers, is 0.6 kg./hr. These figures do not reflect the Samoans' esteem for the nearshore marine life caught with each technique, and there is certainly a wide variety in the catch.

The yield per unit area for the fringing reef was calculated to be 119 kgs./ha./yr., or roughly 12 M.T./km^2/yr.

This yield, consisting of numerous species of small fish and many invertebrates (35% of total), is six times as great as the average yield of tropical demersal fisheries studied by Stevenson and Marshall (1974). It attests to the high productivity of shallow coral reefs and to the ability of native populations in the Pacific to harvest this diverse produce.

Unfortunately the subsistence fishery has over-exploited the fringing reefs in American Samoa. In the face of the territory's population explosion and urban development fishing pressure has exceeded the reef's ability to produce, and the reefs are doubtlessly yielding catches below their potential. The nearshore fishery is sorely in need of an enlightened and effective program of marine resource management.

The catch for the nearshore fishery is equal to approximately 65 metric tons per year. While the value of the increased production accompanying effective management of the fishery may not warrant the expenditure of large sums in developing such management, it is proposed that the revitalization of traditional forms of reef conservation and preservation may accomplish the needed reef management. In particular, the translation of formal fisheries management into the "kapu" or "sa" (prohibition) system and the reinstatement of the village "fonos" as overseers of the reef are recommended.

Table 27. Crosstabulation of the age composition of fishing groups by their sex composition

AGEMIX	COUNT / ROW PCT / COL PCT / TOT PCT	SEXMIX: UNMIXED 1	MIXED 2	ROW TOTAL
UNMIXED	1	491	69	560
		87.7	12.3	58.8
		72.3	25.3	
		51.6	7.2	
MIXED	2	188	204	392
		48.0	52.0	41.2
		27.7	74.7	
		19.7	21.4	
	COLUMN TOTAL	679	273	952
		71.3	28.7	100.0

Table 28. Crosstabulation of the primary subsistence fishery activities by their sex composition, controlling for their age composition

AGEMIX: Unmixed

FISHACT	COUNT / ROW PCT / COL PCT / TOT PCT	SEXMIX: UNMIXED 1	MIXED 2	ROW TOTAL
0 PAOPAO ACTIVITY	COUNT	11	2	13
	ROW PCT	84.6	15.4	2.5
	COL PCT	2.4	2.9	
	TOT PCT	2.1	0.4	
1 WALKING-GLEANING	COUNT	103	31	134
	ROW PCT	76.9	23.1	25.3
	COL PCT	22.3	45.6	
	TOT PCT	19.4	5.8	
2 DIVING	COUNT	178	6	184
	ROW PCT	96.7	3.3	34.7
	COL PCT	38.5	8.8	
	TOT PCT	33.6	1.1	
3 FISHING, POLE-BA	COUNT	83	16	99
	ROW PCT	83.8	16.2	18.7
	COL PCT	18.0	23.5	
	TOT PCT	15.7	3.0	
4 FISHING, POLE-FL	COUNT	6	0	6
	ROW PCT	100.0	0.0	1.1
	COL PCT	1.3	0.0	
	TOT PCT	1.1	0.0	
5 FISHING, ROD	COUNT	14	0	14
	ROW PCT	100.0	0.0	2.6
	COL PCT	3.0	0.0	
	TOT PCT	2.6	0.0	
6 THROWNET FISHING	COUNT	42	1	43
	ROW PCT	97.7	2.3	8.1
	COL PCT	9.1	1.5	
	TOT PCT	7.9	0.2	
7 GILL NET OR TRAP	COUNT	23	7	30
	ROW PCT	76.7	23.3	5.7
	COL PCT	5.0	10.3	
	TOT PCT	4.3	1.3	
8 OTHER METHODS	COUNT	2	5	7
	ROW PCT	28.6	71.4	1.3
	COL PCT	0.4	7.4	
	TOT PCT	0.4	0.9	
COLUMN TOTAL		462	68	530
		87.2	12.8	100.0

AGEMIX: Mixed

FISHACT	COUNT / ROW PCT / COL PCT / TOT PCT	SEXMIX: UNMIXED 1	MIXED 2	ROW TOTAL
0 PAOPAO ACTIVITY	COUNT	12	0	12
	ROW PCT	100.0	0.0	3.2
	COL PCT	6.7	0.0	
	TOT PCT	3.2	0.0	
1 WALKING-GLEANING	COUNT	87	153	240
	ROW PCT	36.3	63.8	64.3
	COL PCT	48.9	78.5	
	TOT PCT	23.3	41.0	
2 DIVING	COUNT	22	5	27
	ROW PCT	81.5	18.5	7.2
	COL PCT	12.4	2.6	
	TOT PCT	5.9	1.3	
3 FISHING, POLE-BA	COUNT	33	26	59
	ROW PCT	55.9	44.1	15.8
	COL PCT	18.5	13.3	
	TOT PCT	8.8	7.0	
4 FISHING, POLE-FL	COUNT	2	0	2
	ROW PCT	100.0	0.0	0.5
	COL PCT	1.1	0.0	
	TOT PCT	0.5	0.0	
5 FISHING, ROD	COUNT	1	0	1
	ROW PCT	100.0	0.0	0.3
	COL PCT	0.6	0.0	
	TOT PCT	0.3	0.0	
6 THROWNET FISHING	COUNT	4	0	4
	ROW PCT	100.0	0.0	1.1
	COL PCT	2.2	0.0	
	TOT PCT	1.1	0.0	
7 GILL NET OR TRAP	COUNT	17	8	25
	ROW PCT	68.0	32.0	6.7
	COL PCT	9.6	4.1	
	TOT PCT	4.6	2.1	
8 OTHER METHODS	COUNT	0	3	3
	ROW PCT	0.0	100.0	0.8
	COL PCT	0.0	1.5	
	TOT PCT	0.0	0.8	
COLUMN TOTAL		178	195	373
		47.7	52.3	100.0

Table 29. Crosstabulations of the primary subsistence fishery participants by the age composition and by the sex composition of the groups of participants

AGEMIX (COUNT / ROW PCT / COL PCT / TOT PCT)

AGESEX		UNMIXED 1	MIXED 2	ROW TOTAL
1 MALE CHILDREN	COUNT	93	111	204
	ROW PCT	45.6	54.4	21.6
	COL PCT	16.6	28.9	
	TOT PCT	9.9	11.8	
2 FEMALE CHILDREN	COUNT	20	72	92
	ROW PCT	21.7	78.3	9.7
	COL PCT	3.6	18.8	
	TOT PCT	2.1	7.6	
3 ADOLES. MALES	COUNT	108	28	136
	ROW PCT	79.4	20.6	14.4
	COL PCT	19.3	7.3	
	TOT PCT	11.4	3.0	
4 ADOLES. FEMALES	COUNT	41	22	63
	ROW PCT	65.1	34.9	6.7
	COL PCT	7.3	5.7	
	TOT PCT	4.3	2.3	
5 ADULT MALES	COUNT	226	34	260
	ROW PCT	86.9	13.1	27.5
	COL PCT	40.4	8.9	
	TOT PCT	23.9	3.6	
6 ADULT FEMALES	COUNT	66	91	157
	ROW PCT	42.0	58.0	16.6
	COL PCT	11.8	23.7	
	TOT PCT	7.0	9.6	
7 ELDERLY MALES	COUNT	1	5	6
	ROW PCT	16.7	83.3	0.6
	COL PCT	0.2	1.3	
	TOT PCT	0.1	0.5	
8 ELDERLY FEMALES	COUNT	4	12	16
	ROW PCT	25.0	75.0	1.7
	COL PCT	0.7	3.1	
	TOT PCT	0.4	1.3	
9 MALE, NON-CHILD	COUNT	0	9	9
	ROW PCT	0.0	100.0	1.0
	COL PCT	0.0	2.3	
	TOT PCT	0.0	1.0	
10 FEMALE, NON-CHIL	COUNT	1	0	1
	ROW PCT	100.0	0.0	0.1
	COL PCT	0.2	0.0	
	TOT PCT	0.1	0.0	
COLUMN TOTAL		560	384	944
		59.3	40.7	100.0

SEXMIX (COUNT / ROW PCT / COL PCT / TOT PCT)

AGESEX		UNMIXED 1	MIXED 2	ROW TOTAL
1 MALE CHILDREN	COUNT	129	75	204
	ROW PCT	63.2	36.8	21.5
	COL PCT	18.9	28.3	
	TOT PCT	13.6	7.9	
2 FEMALE CHILDREN	COUNT	47	45	92
	ROW PCT	51.1	48.9	9.7
	COL PCT	6.9	17.0	
	TOT PCT	5.0	4.7	
3 ADOLES. MALES	COUNT	127	9	136
	ROW PCT	93.4	6.6	14.3
	COL PCT	18.6	3.4	
	TOT PCT	13.4	0.9	
4 ADOLES. FEMALES	COUNT	40	23	63
	ROW PCT	63.5	36.5	6.6
	COL PCT	5.8	8.7	
	TOT PCT	4.2	2.4	
5 ADULT MALES	COUNT	238	24	262
	ROW PCT	90.8	9.2	27.6
	COL PCT	34.8	9.1	
	TOT PCT	25.1	2.5	
6 ADULT FEMALES	COUNT	76	81	157
	ROW PCT	48.4	51.6	16.5
	COL PCT	11.1	30.6	
	TOT PCT	8.0	8.5	
7 ELDERLY MALES	COUNT	4	2	6
	ROW PCT	66.7	33.3	0.6
	COL PCT	0.6	0.8	
	TOT PCT	0.4	0.2	
8 ELDERLY FEMALES	COUNT	10	6	16
	ROW PCT	62.5	37.5	1.7
	COL PCT	1.5	2.3	
	TOT PCT	1.1	0.6	
9 MALE, NON-CHILD	COUNT	12	0	12
	ROW PCT	100.0	0.0	1.3
	COL PCT	1.8	0.0	
	TOT PCT	1.3	0.0	
10 FEMALE, NON-CHIL	COUNT	1	0	1
	ROW PCT	100.0	0.0	0.1
	COL PCT	0.1	0.0	
	TOT PCT	0.1	0.0	
COLUMN TOTAL		684	265	949
		72.1	27.9	100.0

Table 30. Frequencies with which the different reef locations were observed as the sites for the different primary subsistence fishery activities

CATEGORY LABEL	CODE	ABSOLUTE FREQUENCY	RELATIVE FREQUENCY (PERCENT)	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
SHORE	0	155	13.4	15.4	15.4
INNER REEF	1	116	10.0	11.5	26.9
MID REEF	2	232	20.1	23.0	49.9
OUTER REEF	3	186	16.1	18.4	68.3
REEF MARGIN	4	195	16.9	19.3	87.6
AWA-REEF FRONT	5	110	9.5	10.9	98.5
DEEP WATER	6	15	1.3	1.5	100.0
IN TRANSIT	7	113	9.8	MISSING	100.0
EMPTY SET	9	33	2.9	MISSING	100.0
	TOTAL	1155	100.0	100.0	

Table 31. Crosstabulation of the primary subsistence fishery activities by their reef locations, controlling for tidal height

Very Low Tide

FISHACT	REEFLOC: COUNT / ROW PCT / COL PCT / TOT PCT	SHORE 0	INNER REEF 1	MID REEF 2	OUTER REEF 3	REEF MARGIN 4	AWA-REEF FRONT 5	DEEP WATER 6	ROW TOTAL
0 PAOPAO ACTIVITY	COUNT	0	0	0	2	3	4	0	9
	ROW PCT	0.0	0.0	0.0	22.2	33.3	44.4	0.0	1.5
	COL PCT	0.0	0.0	0.0	1.1	2.3	7.1	0.0	
	TOT PCT	0.0	0.0	0.0	0.3	0.5	0.7	0.0	
1 WALKING-GLEANING	COUNT	0	46	110	156	35	0	0	347
	ROW PCT	0.0	13.3	31.7	45.0	10.1	0.0	0.0	58.9
	COL PCT	0.0	74.2	84.6	88.6	26.3	0.0	0.0	
	TOT PCT	0.0	7.8	18.7	26.5	5.9	0.0	0.0	
2 DIVING	COUNT	0	10	14	2	2	52	6	86
	ROW PCT	0.0	11.6	16.3	2.3	2.3	60.5	7.0	14.6
	COL PCT	0.0	16.1	10.8	1.1	1.5	92.9	100.0	
	TOT PCT	0.0	1.7	2.4	0.3	0.3	8.8	1.0	
3 FISHING, POLE-BA	COUNT	18	1	2	2	40	0	0	63
	ROW PCT	28.6	1.6	3.2	3.2	63.5	0.0	0.0	10.7
	COL PCT	69.2	1.6	1.5	1.1	30.1	0.0	0.0	
	TOT PCT	3.1	0.2	0.3	0.3	6.8	0.0	0.0	
4 FISHING, POLE-FL	COUNT	0	0	3	4	10	0	0	17
	ROW PCT	0.0	0.0	17.6	23.5	58.8	0.0	0.0	2.9
	COL PCT	0.0	0.0	2.3	2.3	7.5	0.0	0.0	
	TOT PCT	0.0	0.0	0.5	0.7	1.7	0.0	0.0	
5 FISHING, ROD	COUNT	1	0	1	2	16	0	0	20
	ROW PCT	5.0	0.0	5.0	10.0	80.0	0.0	0.0	3.4
	COL PCT	3.8	0.0	0.8	1.1	12.0	0.0	0.0	
	TOT PCT	0.2	0.0	0.2	0.3	2.7	0.0	0.0	
6 THROWNET FISHING	COUNT	7	1	0	8	14	0	0	30
	ROW PCT	23.3	3.3	0.0	26.7	46.7	0.0	0.0	5.1
	COL PCT	26.9	1.6	0.0	4.5	10.5	0.0	0.0	
	TOT PCT	1.2	0.2	0.0	1.4	2.4	0.0	0.0	
7 GILL NET OR TRAP	COUNT	0	0	0	0	13	0	0	13
	ROW PCT	0.0	0.0	0.0	0.0	100.0	0.0	0.0	2.2
	COL PCT	0.0	0.0	0.0	0.0	9.8	0.0	0.0	
	TOT PCT	0.0	0.0	0.0	0.0	2.2	0.0	0.0	
8 OTHER METHODS	COUNT	0	4	0	0	0	0	0	4
	ROW PCT	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.7
	COL PCT	0.0	6.5	0.0	0.0	0.0	0.0	0.0	
	TOT PCT	0.0	0.7	0.0	0.0	0.0	0.0	0.0	
COLUMN TOTAL		26	62	130	176	133	56	6	589
		4.4	10.5	22.1	29.9	22.6	9.5	1.0	100.0

Table 32. Crosstabulation of the primary subsistence fishery activities by their reef locations, controlling for tidal height

Low Tide

FISHACT	COUNT / ROW PCT / COL PCT / TOT PCT	REEFLOC: ISHORE 0	INNER REEF 1	MID REEF 2	OUTER REEF 3	REEF MARGIN 4	AWA-REEF FRONT 5	DEEP WATER 6	ROW TOTAL
0 PAOPAO ACTIVITY	COUNT	0	2	0	2	0	9	8	21
	ROW PCT	0.0	9.5	0.0	9.5	0.0	42.9	38.1	6.4
	COL PCT	0.0	3.6	0.0	6.1	0.0	26.5	80.0	
	TOT PCT	0.0	0.6	0.0	0.6	0.0	2.7	2.4	
1 WALKING-GLEANING	COUNT	0	23	49	23	3	1	0	99
	ROW PCT	0.0	23.2	49.5	23.2	3.0	1.0	0.0	30.1
	COL PCT	0.0	41.8	61.3	69.7	5.2	2.9	0.0	
	TOT PCT	0.0	7.0	14.9	7.0	0.9	0.3	0.0	
2 DIVING	COUNT	0	17	20	2	9	24	2	74
	ROW PCT	0.0	23.0	27.0	2.7	12.2	32.4	2.7	22.5
	COL PCT	0.0	30.9	25.0	6.1	15.5	70.6	20.0	
	TOT PCT	0.0	5.2	6.1	0.6	2.7	7.3	0.6	
3 FISHING, POLE-BA	COUNT	51	6	6	0	21	0	0	84
	ROW PCT	60.7	7.1	7.1	0.0	25.0	0.0	0.0	25.5
	COL PCT	86.4	10.9	7.5	0.0	36.2	0.0	0.0	
	TOT PCT	15.5	1.8	1.8	0.0	6.4	0.0	0.0	
4 FISHING, POLE-FL	COUNT	0	0	0	0	1	0	0	1
	ROW PCT	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.3
	COL PCT	0.0	0.0	0.0	0.0	1.7	0.0	0.0	
	TOT PCT	0.0	0.0	0.0	0.0	0.3	0.0	0.0	
5 FISHING, ROD	COUNT	3	1	3	0	5	0	0	12
	ROW PCT	25.0	8.3	25.0	0.0	41.7	0.0	0.0	3.6
	COL PCT	5.1	1.8	3.8	0.0	8.6	0.0	0.0	
	TOT PCT	0.9	0.3	0.9	0.0	1.5	0.0	0.0	
6 THROWNET FISHING	COUNT	5	1	0	0	5	0	0	11
	ROW PCT	45.5	9.1	0.0	0.0	45.5	0.0	0.0	3.3
	COL PCT	8.5	1.8	0.0	0.0	8.6	0.0	0.0	
	TOT PCT	1.5	0.3	0.0	0.0	1.5	0.0	0.0	
7 GILL NET OR TRAP	COUNT	0	0	0	6	14	0	0	20
	ROW PCT	0.0	0.0	0.0	30.0	70.0	0.0	0.0	6.1
	COL PCT	0.0	0.0	0.0	18.2	24.1	0.0	0.0	
	TOT PCT	0.0	0.0	0.0	1.8	4.3	0.0	0.0	
8 OTHER METHODS	COUNT	0	5	2	0	0	0	0	7
	ROW PCT	0.0	71.4	28.6	0.0	0.0	0.0	0.0	2.1
	COL PCT	0.0	9.1	2.5	0.0	0.0	0.0	0.0	
	TOT PCT	0.0	1.5	0.6	0.0	0.0	0.0	0.0	
COLUMN TOTAL		59	55	80	33	58	34	10	329
		17.9	16.7	24.3	10.0	17.6	10.3	3.0	100.0

Table 33. Crosstabulation of the primary subsistence fishery activities by their reef locations, controlling for tidal height

Mid Tide

FISHACT	COUNT / ROW PCT / COL PCT / TOT PCT	REEFLOC SHORE 0	INNER REEF 1	MID REEF 2	OUTER REEF 3	REEF MARGIN 4	AWA-REEF FRONT 5	DEEP WATER 6	ROW TOTAL
0 PAOPAO ACTIVITY	COUNT	0	0	2	2	0	3	2	9
	ROW PCT	0.0	0.0	22.2	22.2	0.0	33.3	22.2	5.0
	COL PCT	0.0	0.0	4.3	18.2	0.0	13.6	100.0	
	TOT PCT	0.0	0.0	1.1	1.1	0.0	1.7	1.1	
1 WALKING-GLEANING	COUNT	0	5	3	0	0	0	0	8
	ROW PCT	0.0	62.5	37.5	0.0	0.0	0.0	0.0	4.4
	COL PCT	0.0	26.3	6.5	0.0	0.0	0.0	0.0	
	TOT PCT	0.0	2.8	1.7	0.0	0.0	0.0	0.0	
2 DIVING	COUNT	0	8	32	8	19	19	0	86
	ROW PCT	0.0	9.3	37.2	9.3	22.1	22.1	0.0	47.5
	COL PCT	0.0	42.1	69.6	72.7	86.4	86.4	0.0	
	TOT PCT	0.0	4.4	17.7	4.4	10.5	10.5	0.0	
3 FISHING, POLE-BA	COUNT	45	4	4	0	0	0	0	53
	ROW PCT	84.9	7.5	7.5	0.0	0.0	0.0	0.0	29.3
	COL PCT	76.3	21.1	8.7	0.0	0.0	0.0	0.0	
	TOT PCT	24.9	2.2	2.2	0.0	0.0	0.0	0.0	
4 FISHING, POLE-FL	COUNT	0	0	0	1	0	0	0	1
	ROW PCT	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.6
	COL PCT	0.0	0.0	0.0	9.1	0.0	0.0	0.0	
	TOT PCT	0.0	0.0	0.0	0.6	0.0	0.0	0.0	
5 FISHING, ROD	COUNT	2	1	2	0	0	0	0	5
	ROW PCT	40.0	20.0	40.0	0.0	0.0	0.0	0.0	2.8
	COL PCT	3.4	5.3	4.3	0.0	0.0	0.0	0.0	
	TOT PCT	1.1	0.6	1.1	0.0	0.0	0.0	0.0	
6 THROWNET FISHING	COUNT	8	1	0	0	0	0	0	9
	ROW PCT	88.9	11.1	0.0	0.0	0.0	0.0	0.0	5.0
	COL PCT	13.6	5.3	0.0	0.0	0.0	0.0	0.0	
	TOT PCT	4.4	0.6	0.0	0.0	0.0	0.0	0.0	
7 GILL NET OR TRAP	COUNT	4	0	3	0	3	0	0	10
	ROW PCT	40.0	0.0	30.0	0.0	30.0	0.0	0.0	5.5
	COL PCT	6.8	0.0	6.5	0.0	13.6	0.0	0.0	
	TOT PCT	2.2	0.0	1.7	0.0	1.7	0.0	0.0	
COLUMN TOTAL		59	19	46	11	22	22	2	181
		32.6	10.5	25.4	6.1	12.2	12.2	1.1	100.0

Table 34. Crosstabulation of the primary subsistence fishery activities by their reef locations, controlling for tidal height

High Tide

FISHACT	REEFLOC: COUNT / ROW PCT / COL PCT / TOT PCT	SHORE 0	INNER REEF 1	MID REEF 2	OUTER REEF 3	REEF MARGIN 4	AWA-REEF FRONT 5	ROW TOTAL
0 PAOFAO ACTIVITY	COUNT	0	2	1	0	0	1	4
	ROW PCT	0.0	50.0	25.0	0.0	0.0	25.0	6.3
	COL PCT	0.0	25.0	12.5	0.0	0.0	6.7	
	TOT PCT	0.0	3.1	1.6	0.0	0.0	1.6	
1 WALKING-GLEANING	COUNT	0	0	1	0	0	0	1
	ROW PCT	0.0	0.0	100.0	0.0	0.0	0.0	1.6
	COL PCT	0.0	0.0	12.5	0.0	0.0	0.0	
	TOT PCT	0.0	0.0	1.6	0.0	0.0	0.0	
2 DIVING	COUNT	0	6	5	1	1	14	27
	ROW PCT	0.0	22.2	18.5	3.7	3.7	51.9	42.2
	COL PCT	0.0	75.0	62.5	100.0	33.3	93.3	
	TOT PCT	0.0	9.4	7.8	1.6	1.6	21.9	
3 FISHING, PCLE-BA	COUNT	22	0	1	0	0	0	23
	ROW PCT	95.7	0.0	4.3	0.0	0.0	0.0	35.9
	COL PCT	75.9	0.0	12.5	0.0	0.0	0.0	
	TOT PCT	34.4	0.0	1.6	0.0	0.0	0.0	
5 FISHING, ROD	COUNT	6	0	0	0	0	0	6
	ROW PCT	100.0	0.0	0.0	0.0	0.0	0.0	9.4
	COL PCT	20.7	0.0	0.0	0.0	0.0	0.0	
	TOT PCT	9.4	0.0	0.0	0.0	0.0	0.0	
6 THROWNET FISHING	COUNT	1	0	0	0	2	0	3
	ROW PCT	33.3	0.0	0.0	0.0	66.7	0.0	4.7
	COL PCT	3.4	0.0	0.0	0.0	66.7	0.0	
	TOT PCT	1.6	0.0	0.0	0.0	3.1	0.0	
CCLUMN TOTAL		29	8	8	1	3	15	64
		45.3	12.5	12.5	1.6	4.7	23.4	100.0

Table 35. Crosstabulation of the primary subsistence fishery activities by their reef locations, controlling for tidal period

Low Period

FISHACT	REEFLOC: COUNT / ROW PCT / COL PCT / TOT PCT	SHORE 0	INNER REEF 1	MID REEF 2	OUTER REEF 3	REEF MARGIN 4	AWA-REEF FRONT 5	DEEP WATER 6	ROW TOTAL
0 PACPAO ACTIVITY	COUNT	0	0	0	2	3	4	1	10
	ROW PCT	0.0	0.0	0.0	20.0	30.0	40.0	10.0	1.5
	COL PCT	0.0	0.0	0.0	1.0	2.1	6.2	11.1	
	TOT PCT	0.0	0.0	0.0	0.3	0.4	0.6	0.1	
1 WALKING-GLEANING	COUNT	0	55	141	175	35	0	0	406
	ROW PCT	0.0	13.5	34.7	43.1	8.6	0.0	0.0	59.3
	COL PCT	0.0	76.4	83.4	88.8	24.5	0.0	0.0	
	TOT PCT	0.0	8.0	20.6	25.5	5.1	0.0	0.0	
2 DIVING	COUNT	0	11	19	2	2	61	8	103
	ROW PCT	0.0	10.7	18.4	1.9	1.9	59.2	7.8	15.0
	COL PCT	0.0	15.3	11.2	1.0	1.4	93.8	88.9	
	TOT PCT	0.0	1.6	2.8	0.3	0.3	8.9	1.2	
3 FISHING, POLE-BA	COUNT	22	1	2	2	50	0	0	77
	ROW PCT	28.6	1.3	2.6	2.6	64.9	0.0	0.0	11.2
	COL PCT	73.3	1.4	1.2	1.0	35.0	0.0	0.0	
	TOT PCT	3.2	0.1	0.3	0.3	7.3	0.0	0.0	
4 FISHING, POLE-FL	COUNT	0	0	3	4	10	0	0	17
	ROW PCT	0.0	0.0	17.6	23.5	58.8	0.0	0.0	2.5
	COL PCT	0.0	0.0	1.8	2.0	7.0	0.0	0.0	
	TOT PCT	0.0	0.0	0.4	0.6	1.5	0.0	0.0	
5 FISHING, ROD	COUNT	1	0	2	2	16	0	0	21
	ROW PCT	4.8	0.0	9.5	9.5	76.2	0.0	0.0	3.1
	COL PCT	3.3	0.0	1.2	1.0	11.2	0.0	0.0	
	TOT PCT	0.1	0.0	0.3	0.3	2.3	0.0	0.0	
6 THROWNET FISHING	COUNT	7	1	0	8	14	0	0	30
	ROW PCT	23.3	3.3	0.0	26.7	46.7	0.0	0.0	4.4
	COL PCT	23.3	1.4	0.0	4.1	9.8	0.0	0.0	
	TOT PCT	1.0	0.1	0.0	1.2	2.0	0.0	0.0	
7 GILL NET OR TRAP	COUNT	0	0	0	2	13	0	0	15
	ROW PCT	0.0	0.0	0.0	13.3	86.7	0.0	0.0	2.2
	COL PCT	0.0	0.0	0.0	1.0	9.1	0.0	0.0	
	TOT PCT	0.0	0.0	0.0	0.3	1.9	0.0	0.0	
8 OTHER METHODS	COUNT	0	4	2	0	0	0	0	6
	ROW PCT	0.0	66.7	33.3	0.0	0.0	0.0	0.0	0.9
	COL PCT	0.0	5.6	1.2	0.0	0.0	0.0	0.0	
	TOT PCT	0.0	0.6	0.3	0.0	0.0	0.0	0.0	
COLUMN TOTAL		30	72	169	197	143	65	9	685
		4.4	10.5	24.7	28.8	20.9	9.5	1.3	100.0

Table 36. Crosstabulation of the primary subsistence fishery activities by their reef locations, controlling for tidal period

Mid Period

FISHACT	COUNT / ROW PCT / COL PCT / TOT PCT	REEFLOC: SHORE 0	INNER REEF 1	MID REEF 2	OUTER REEF 3	REEF MARGIN 4	AWA-REEF FRONT 5	DEEP WATER 6	ROW TOTAL
0 PAOPAO ACTIVITY	COUNT	0	2	0	2	0	12	9	25
	ROW PCT	0.0	8.0	0.0	8.0	0.0	48.0	36.0	6.7
	COL PCT	0.0	3.4	0.0	9.5	0.0	28.6	100.0	
	TOT PCT	0.0	0.5	0.0	0.5	0.0	3.2	2.4	
1 WALKING-GLEANING	COUNT	0	19	21	4	3	1	0	48
	ROW PCT	0.0	39.6	43.8	8.3	6.3	2.1	0.0	12.8
	COL PCT	0.0	32.2	28.4	19.0	4.4	2.4	0.0	
	TOT PCT	0.0	5.1	5.6	1.1	0.8	0.3	0.0	
2 DIVING	COUNT	0	24	38	10	26	29	0	127
	ROW PCT	0.0	18.9	29.9	7.9	20.5	22.8	0.0	33.9
	COL PCT	0.0	40.7	51.4	47.6	38.2	69.0	0.0	
	TOT PCT	0.0	6.4	10.1	2.7	6.9	7.7	0.0	
3 FISHING, POLE-BA	COUNT	82	6	10	0	11	0	0	109
	ROW PCT	75.2	5.5	9.2	0.0	10.1	0.0	0.0	29.1
	COL PCT	80.4	10.2	13.5	0.0	16.2	0.0	0.0	
	TOT PCT	21.9	1.6	2.7	0.0	2.9	0.0	0.0	
4 FISHING, POLE-FL	COUNT	0	0	0	1	1	0	0	2
	ROW PCT	0.0	0.0	0.0	50.0	50.0	0.0	0.0	0.5
	COL PCT	0.0	0.0	0.0	4.8	1.5	0.0	0.0	
	TOT PCT	0.0	0.0	0.0	0.3	0.3	0.0	0.0	
5 FISHING, ROD	COUNT	4	1	2	0	5	0	0	12
	ROW PCT	33.3	8.3	16.7	0.0	41.7	0.0	0.0	3.2
	COL PCT	3.9	1.7	2.7	0.0	7.4	0.0	0.0	
	TOT PCT	1.1	0.3	0.5	0.0	1.3	0.0	0.0	
6 THROWNET FISHING	COUNT	12	2	0	0	5	0	0	19
	ROW PCT	63.2	10.5	0.0	0.0	26.3	0.0	0.0	5.1
	COL PCT	11.8	3.4	0.0	0.0	7.4	0.0	0.0	
	TOT PCT	3.2	0.5	0.0	0.0	1.3	0.0	0.0	
7 GILL NET OR TRAP	COUNT	4	0	3	4	17	0	0	28
	ROW PCT	14.3	0.0	10.7	14.3	60.7	0.0	0.0	7.5
	COL PCT	3.9	0.0	4.1	19.0	25.0	0.0	0.0	
	TOT PCT	1.1	0.0	0.8	1.1	4.5	0.0	0.0	
8 OTHER METHODS	COUNT	0	5	0	0	0	0	0	5
	ROW PCT	0.0	100.0	0.0	0.0	0.0	0.0	0.0	1.3
	COL PCT	0.0	8.5	0.0	0.0	0.0	0.0	0.0	
	TOT PCT	0.0	1.3	0.0	0.0	0.0	0.0	0.0	
COLUMN TOTAL		102	59	74	21	68	42	9	375
		27.2	15.7	19.7	5.6	18.1	11.2	2.4	100.0

Table 37. Crosstabulation of the primary subsistence fishery activities by their reef locations, controlling for tidal period

High Period

FISHACT	COUNT / ROW PCT / COL PCT / TOT PCT	REEFLOC: ISHORE 0	INNER REEF 1	MID REEF 2	OUTER REEF 3	REEF MARGIN 4	AWA-REEF FRONT 5	ROW TOTAL
0 PAOPAO ACTIVITY	COUNT	0	2	3	2	0	1	8
	ROW PCT	0.0	25.0	37.5	25.0	0.0	12.5	7.8
	COL PCT	0.0	15.4	14.3	66.7	0.0	5.0	
	TOT PCT	0.0	1.9	2.9	1.9	0.0	1.0	
1 WALKING-GLEANING	COUNT	0	0	1	0	0	0	1
	ROW PCT	0.0	0.0	100.0	0.0	0.0	0.0	1.0
	COL PCT	0.0	0.0	4.8	0.0	0.0	0.0	
	TOT PCT	0.0	0.0	1.0	0.0	0.0	0.0	
2 DIVING	COUNT	0	6	14	1	3	19	43
	ROW PCT	0.0	14.0	32.6	2.3	7.0	44.2	41.7
	COL PCT	0.0	46.2	66.7	33.3	60.0	95.0	
	TOT PCT	0.0	5.8	13.6	1.0	2.9	18.4	
3 FISHING, POLE-BA	COUNT	32	4	1	0	0	0	37
	ROW PCT	86.5	10.8	2.7	0.0	0.0	0.0	35.9
	COL PCT	78.0	30.8	4.8	0.0	0.0	0.0	
	TOT PCT	31.1	3.9	1.0	0.0	0.0	0.0	
5 FISHING, ROD	COUNT	7	1	2	0	0	0	10
	ROW PCT	70.0	10.0	20.0	0.0	0.0	0.0	9.7
	COL PCT	17.1	7.7	9.5	0.0	0.0	0.0	
	TOT PCT	6.8	1.0	1.9	0.0	0.0	0.0	
6 THROWNET FISHING	COUNT	2	0	0	0	2	0	4
	ROW PCT	50.0	0.0	0.0	0.0	50.0	0.0	3.9
	COL PCT	4.9	0.0	0.0	0.0	40.0	0.0	
	TOT PCT	1.9	0.0	0.0	0.0	1.9	0.0	
COLUMN TOTAL		41	13	21	3	5	20	103
		39.8	12.6	20.4	2.9	4.9	19.4	100.0

Table 38. Crosstabulation of the adjacent shoreline by the primary subsistence fishery activities, controlling for tidal height

Very Low Tide

VILLSITE / FISHACT (COUNT / ROW PCT / COL PCT / TOT PCT)	PAOPAO A CTIVITY 0	WALKING- GLEANING 1	DIVING 2	FISHING, POLE-BA 3	FISHING, POLE-FL 4	FISHING, ROD 5	THROWNET FISHING 6	GILL NET OR TRAP 7	OTHER ME THODS 8	ROW TOTAL
23	2	197	57	16	4	6	13	13	4	312
OPEN SEA'S SHORE	0.6	63.1	18.3	5.1	1.3	1.9	4.2	4.2	1.3	54.5
	14.3	62.5	60.0	27.6	23.5	30.0	36.1	100.0	100.0	
	0.3	34.4	10.0	2.8	0.7	1.0	2.3	2.3	0.7	
24	12	118	38	42	13	14	23	0	0	260
PAGO BAY'S SHORE	4.6	45.4	14.6	16.2	5.0	5.4	8.8	0.0	0.0	45.5
	85.7	37.5	40.0	72.4	76.5	70.0	63.9	0.0	0.0	
	2.1	20.6	6.6	7.3	2.3	2.4	4.0	0.0	0.0	
COLUMN	14	315	95	58	17	20	36	13	4	572
TOTAL	2.4	55.1	16.6	10.1	3.0	3.5	6.3	2.3	0.7	100.0

Table 39. Crosstabulation of the adjacent shoreline by the primary subsistence fishery activities, controlling for tidal height

Low Tide

VILLSITE / FISHACT (COUNT / ROW PCT / COL PCT / TOT PCT)	PAOPAO A CTIVITY 0	WALKING- GLEANING 1	DIVING 2	FISHING, POLE-BA 3	FISHING, POLE-FL 4	FISHING, ROD 5	THROWNET FISHING 6	GILL NET OR TRAP 7	OTHER ME THODS 8	ROW TOTAL
23	11	51	39	5	4	4	5	13	5	137
OPEN SEA'S SHORE	8.0	37.2	28.5	3.6	2.9	2.9	3.6	9.5	3.6	43.9
	52.4	60.7	52.7	6.8	100.0	33.3	35.7	59.1	71.4	
	3.5	16.3	12.5	1.6	1.3	1.3	1.6	4.2	1.6	
24	10	33	35	69	0	8	9	9	2	175
PAGO BAY'S SHORE	5.7	18.9	20.0	39.4	0.0	4.6	5.1	5.1	1.1	56.1
	47.6	39.3	47.3	93.2	0.0	66.7	64.3	40.9	28.6	
	3.2	10.6	11.2	22.1	0.0	2.6	2.9	2.9	0.6	
COLUMN	21	84	74	74	4	12	14	22	7	312
TOTAL	6.7	26.9	23.7	23.7	1.3	3.8	4.5	7.1	2.2	100.0

Table 40. Crosstabulation of the adjacent shoreline by the primary subsistence fishery activities, controlling for tidal height

Mid Tide

VILLSITE	FISHACT: COUNT / ROW PCT / COL PCT / TOT PCT	PAOPAO ACTIVITY 0	WALKING-GLEANING 1	DIVING 2	FISHING, POLE-BA 3	FISHING, POLE-FL 4	FISHING, ROD 5	THROWNET FISHING 6	GILL NET OR TRAP 7	ROW TOTAL
23 OPEN SEA'S SHORE	COUNT	2	5	35	4	1	0	2	7	56
	ROW PCT	3.6	8.9	62.5	7.1	1.8	0.0	3.6	12.5	37.3
	COL PCT	18.2	62.5	50.0	10.5	100.0	0.0	28.6	58.3	
	TOT PCT	1.3	3.3	23.3	2.7	0.7	0.0	1.3	4.7	
24 PAGO BAY'S SHORE	COUNT	9	3	35	34	0	3	5	5	94
	ROW PCT	9.6	3.2	37.2	36.2	0.0	3.2	5.3	5.3	62.7
	COL PCT	81.8	37.5	50.0	89.5	0.0	100.0	71.4	41.7	
	TOT PCT	6.0	2.0	23.3	22.7	0.0	2.0	3.3	3.3	
COLUMN TOTAL		11	8	70	38	1	3	7	12	150
		7.3	5.3	46.7	25.3	0.7	2.0	4.7	8.0	100.0

Table 41. Crosstabulation of the adjacent shoreline by the primary subsistence fishery activities, controlling for tidal height

High Tide

VILLSITE	FISHACT: COUNT / ROW PCT / COL PCT / TOT PCT	PAOPAO ACTIVITY 0	WALKING-GLEANING 1	DIVING 2	FISHING, POLE-BA 3	FISHING, ROD 5	THROWNET FISHING 6	ROW TOTAL
23 OPEN SEA'S SHORE	COUNT	0	1	13	4	1	3	22
	ROW PCT	0.0	4.5	59.1	18.2	4.5	13.6	30.6
	COL PCT	0.0	100.0	48.1	16.0	16.7	50.0	
	TOT PCT	0.0	1.4	18.1	5.6	1.4	4.2	
24 PAGO BAY'S SHORE	COUNT	7	0	14	21	5	3	50
	ROW PCT	14.0	0.0	28.0	42.0	10.0	6.0	69.4
	COL PCT	100.0	0.0	51.9	84.0	83.3	50.0	
	TOT PCT	9.7	0.0	19.4	29.2	6.9	4.2	
COLUMN TOTAL		7	1	27	25	6	6	72
		9.7	1.4	37.5	34.7	8.3	8.3	100.0

Table 42. Crosstabulation of the shoreline adjacent to the primary subsistence fishery activities by the fishery activities' locations on the reef, controlling for tidal height

Very Low Tide

VILLSITE	REEFLOC: COUNT / ROW PCT / COL PCT / TOT PCT	SHORE 0	INNER REEF 1	MID REEF 2	OUTER REEF 3	REEF MARGIN 4	AWA-REEF FRONT 5	DEEP WATER 6	ROW TOTAL
OPEN SEA'S SHORE	23	5	30	71	91	63	22	4	286
		1.7	10.5	24.8	31.8	22.0	7.7	1.4	54.5
		18.5	71.4	59.2	57.6	50.4	44.9	100.0	
		1.0	5.7	13.5	17.3	12.0	4.2	0.8	
PAGO BAY'S SHORE	24	22	12	49	67	62	27	0	239
		9.2	5.0	20.5	28.0	25.9	11.3	0.0	45.5
		81.5	28.6	40.8	42.4	49.6	55.1	0.0	
		4.2	2.3	9.3	12.8	11.8	5.1	0.0	
COLUMN TOTAL		27	42	120	158	125	49	4	525
		5.1	8.0	22.9	30.1	23.8	9.3	0.8	100.0

Table 43. Crosstabulation of the shoreline adjacent to the primary subsistence fishery activities by the fishery activities' locations on the reef, controlling for tidal height

Low Tide

VILLSITE	REEFLOC: COUNT / ROW PCT / COL PCT / TOT PCT	SHORE 0	INNER REEF 1	MID REEF 2	OUTER REEF 3	REEF MARGIN 4	AWA-REEF FRONT 5	DEEP WATER 6	ROW TOTAL
OPEN SEA'S SHORE	23	1	26	37	8	23	11	7	113
		0.9	23.0	32.7	7.1	20.4	9.7	6.2	39.6
		1.8	50.0	52.1	50.0	43.4	39.3	70.0	
		0.4	9.1	13.0	2.8	8.1	3.9	2.5	
PAGO BAY'S SHORE	24	54	26	34	8	30	17	3	172
		31.4	15.1	19.8	4.7	17.4	9.9	1.7	60.4
		98.2	50.0	47.9	50.0	56.6	60.7	30.0	
		18.9	9.1	11.9	2.8	10.5	6.0	1.1	
COLUMN TOTAL		55	52	71	16	53	28	10	285
		19.3	18.2	24.9	5.6	18.6	9.8	3.5	100.0

Table 44. Crosstabulation of the shoreline adjacent to the primary subsistence fishery activities by the fishery activities' locations on the reef, controlling for tidal height

Mid Tide

VILLSITE	REEFLOC: COUNT / ROW PCT / COL PCT / TOT PCT	SHORE 0	INNER REEF 1	MID REEF 2	OUTER REEF 3	REEF MARGIN 4	AWA-REEF FRONT 5	DEEP WATER 6	ROW TOTAL
23 OPEN SEA'S SHORE	COUNT	8	9	12	9	7	6	1	52
	ROW PCT	15.4	17.3	23.1	17.3	13.5	11.5	1.9	38.2
	COL PCT	18.2	64.3	36.4	81.8	46.7	33.3	100.0	
	TOT PCT	5.9	6.6	8.8	6.6	5.1	4.4	0.7	
24 PAGO BAY'S SHORE	COUNT	36	5	21	2	8	12	0	84
	ROW PCT	42.9	6.0	25.0	2.4	9.5	14.3	0.0	61.8
	COL PCT	81.8	35.7	63.6	18.2	53.3	66.7	0.0	
	TOT PCT	26.5	3.7	15.4	1.5	5.9	8.8	0.0	
COLUMN TOTAL		44	14	33	11	15	18	1	136
		32.4	10.3	24.3	8.1	11.0	13.2	0.7	100.0

Table 45. Crosstabulation of the shoreline adjacent to the primary subsistence fishery activities by the fishery activities' locations on the reef, controlling for tidal height

High Tide

VILLSITE	REEFLOC: COUNT / ROW PCT / COL PCT / TOT PCT	SHORE 0	INNER REEF 1	MID REEF 2	OUTER REEF 3	REEF MARGIN 4	AWA-REEF FRONT 5	ROW TOTAL
23 OPEN SEA'S SHORE	COUNT	4	5	6	0	0	4	19
	ROW PCT	21.1	26.3	31.6	0.0	0.0	21.1	29.7
	COL PCT	13.8	62.5	75.0	0.0	0.0	26.7	
	TOT PCT	6.3	7.8	9.4	0.0	0.0	6.3	
24 PAGO BAY'S SHORE	COUNT	25	3	2	1	3	11	45
	ROW PCT	55.6	6.7	4.4	2.2	6.7	24.4	70.3
	COL PCT	86.2	37.5	25.0	100.0	100.0	73.3	
	TOT PCT	39.1	4.7	3.1	1.6	4.7	17.2	
COLUMN TOTAL		29	8	8	1	3	15	64
		45.3	12.5	12.5	1.6	4.7	23.4	100.0

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